Energy, Mines and Resources Canada

Mineral Processing Laboratory

CANMET

SURVEY OF LITERATURE ON NON-DESTRUCTIVE TESTING OF CONCRETE: 1984 - 1989

by

N.G. Zoldners

FINAL REPORT.

Work on the project was conducted under the auspices of the Canada Centre for Mineral and Energy Technology, EMR Canada. It was supported in part by the Federal Panel on Energy R&D.

DSS FILE NO.: 39SQ.23440-9-9193

DSS CONTRACT SERIAL NO.: 23440-9-9193/01-SQ

CANMET SCIENTIFIC AUTHORITY: Dr. J.A. Soles

76pp

DATE: Nov.1, 1990

MICROMEDIA

NONDESTRUCTIVE TESTING OF CONCRETE:
AN ANNOTATED BIBLIOGRAPHY,
1984 - 1989

1984

1. AKASHI, T. and AMASAKI, S., Ritsumeikan University, Kyoto, Japan, "Study of the stress waves in the plunger of a rebound hammer at the time of impact". In Situ / Nondestructive Testing of Concrete, SP-82, American Concrete Institute, 1984, pp.17-34.

The nature of the stress waves found in the Schmidt test hammer after impact during the testing of concrete were examined experimentally. Using a specially designed plunger, the authors have shown that the impact of the hammer mass produces a large compressive wave σ_i and large reflected stress wave σ_r at the centre of the plunger.The ratio,σ_r/σ_i of the amplitudes of these waves and the time T between their appearance was found to depend upon the surface hardness of cured concrete. The rebound number was found to be approximately proportional to the ratio of the two stresses and was not significantly affected by the moisture conditions of the concrete.The magnitude of the first stress wave at the centre of plunger is almost constant and is approxim. 80% of the value calculated by Schmidt's numerical solution, which does not consider the efficiency of the impact of the hammer.

Keywords: Compressive strength; concrete; impact stress wave; rebound test hammer; rebound number; reflected stress wave; surface hardness; Schmidt test hammer.

---

2. AKMAN, M.S. and GüNER, A.,"Applicability of Sonreb mathod on damaged concrete". Materials and Structures, Research and Testing (RILEM, Paris), V.17. No.99, May-June 1984, pp. 195-200.

In damaged structures, aknowledge of the value of the residual concrete strength is needed as a basis for the decision of reconstructing or repairing and for the design of the repair project. In this work, the limits of applicability of the Sonreb method, a combination of the ultrasonic pulse velocity and the Schmidt index measurement, in the detection of damage caused by high temperatures and chemical attack by ammonium nitrate and ammonium sulfate is discussed. It is concluded that the Sonreb method can be used in assessing the fire-damaged concretes after making a classification of the degree of damage, the duration and the temperature of exposure to fire. In the case of chemical attack, a knowledge is required as to the duration of exposure and the prevailing process of corrosion.

Keywords: Chemical attack; concretes; damage; fire resistance; impact hammer tests; repairs; ultrasonic tests.

3. BICKLEY, J.A., Trow Ltd., Rexdale, Ont.,Canada, "Evaluation and acceptance of concrete quality by in-place testing". In Situ / Nondestructive Testing of Concrete, SP-82, American Concrete Institute, 1984, pp.95-100.

The standard method of determining the quality of hardened concrete is the cylinder test. Unless test results fail to meet specified values, and other test procedures are called into play, cylinder test usually is the only quantitative measure of the quality of concrete in the structure. In two large projects in Toronto,horizontal elements were extensively tested nondestructively by in-place testing for form removal, termination of shoring, and confirmation of specified 28-day compressive strength. Concurrently also cylinders were made and tested.

Keywords: Compressive strength; concrete; impact stress;wave; impact test hammer; form removal; pullout insert; pullout test; standard test procedures; test cylinders; statistical analysis;

4. BOCCA, P., "Application of pull-out test to high-strength concrete estimation". Materials and Structures, Research and Testing (RILEM, Paris), V.17. No.99, May-June 1984, pp.211-216.

The paper compares the results of nondestructive (pullout, pulse velocity, hardness) tests conducted to determine the compressive strength of concrete specimens with strength from 40 to 80 MPa. The pullout method is seen to exhibit greater sensitivity and precision in the results. It is particularly efficient for high-strength concrete (60-80 MPa).In this case it may be convenient to combine the ultrasonic/pullout methods, or else, the ultrasonic/hardness/pullout methods.

Keywords:Compressive strength; high-strength concretes; nondestructive tests; pullout tests.

5. BUNGEY, J.H., University of Liverpool, England, "The influence of reinforcement on ultrasonic pulse velocity testing". In Situ/ Nondestructive Testing of Concrete, SP-82, American Concrete Institute, 1984, pp.229-246.

Embedded reinforcement may have a significant effect on ultrasonic pulse velocity measurements taken through thestructural concrete members. Extensive laboratory experimental work demonstrates major shortcomings in all currently accepted allowance procedures and confirm that bar diameter is an essential variable to be incorporated. The effect of bars passing across the pulse path is shown to be less than for bars of similar size running along the path. A correction procedure is proposed and can meet many practical combinations of bar size, bar orientation and concrete properties with significantly greater accuracy than possible by established methods.

Keywords: Concrete; in-situ testing;effect of reinforcement; ultrasonic pulse velocity method.

6. CANTOR, T.R. and KNEETER, C.P., Port Authority New York, N.Y. U.S.A., "Review of penetration radar as applied to nondestructive evaluation of concrete". In Situ / Nondestructive Testing of Concrete, SP-82, American Concrete Institute, 1984, pp.581--601.

Practical experiences in the use of downward looking penetrating radar as applied to nondestructive evaluation of structures such as bridge decks, roadways and tunnels, are described. Specific operational examples are cited, including automatic signal analysis and processing. Discussion of void and other defect detection is included. The ability of radar to rapidly gather data while moving in traffic at speeds of about 10 mi/hr is reviewed and its implications for pavement management systems are commented on. Case histories are presented.

Keywords: Concrete evaluation; cores; delamination detection; graphic representation; interference (Water, steel); nondestructive evaluation (NDE); permeability of concrete; radar penetration; void detection.

&. CARETTE, G.G. and MALHOTRA, V.M., CANMET, Ottawa,Ont.,Canada. "In-situ tests: variability and strength prediction of concrete at early ages". In Situ / Nondestructive Testing of Concrete, SP-82, American Concrete Institute, 1984, pp.111-141.

This paper reports on an investigation to determine the within-test variability at the ages of 1 to 3 days of various in-situ tests being in use to predict early strength development of concrete for formwork removal purposes. The methods investigated included: penetration resistance, pulse velocity, rebound number and two types of pullout tests. The test results indicate that the pulse velocity method had the least variability and a within-test coeff. of variation of less than 0.5 %, whereas the rebound method had the highest variability in the order of 12%. The values for other in-situ tests ranged from 5 to 10%.

Keywords: Compressive strength; concrete; in-situ testing; form removal; early-age strength; penetration resistance; pulse velocity; pullout test; rebound number; strength prediction; test accuracy; stripping time.

---

8. CARINO, N.J., National Bureau of Standards, Washington, D.C. "Laboratory study of flaw detection in concrete by the pulse--echo method". In Situ / Nondestructive Testing of Concrete, SP-82, American Concrete Institute, 1984, pp.557-579.

A study was performed to evaluate the applicability of using the echoes from mechanically produced impact to locate hidden defects within concrete. The following aspects were studied: type of impact source; distance from impact point to receiver; type of receiving transducer;depth of reflecting interfaces and diffraction effects by sharp edges. The contact time of the impact is shown to be an important parameter.

Keywords: Concrete; contact time; defective concrete; diffraction effect; echo receiver; flaw in concrete; impact source; mechanical impact; pulse echo transducer; reflecting interface.

---

9. CARINO, N.J,, "Maturity method: Theory and application". Cement, Concrete, and Aggregates, V.6, No.2, Winter 1984,pp.61-73.

The maturity method may be used to predict the inplace strength of hardening concrete based on its thermal history. A theoretical basis for the maturity method is presented. The general form of the time-temperature function is found to be the time integral of the rate constant.For the case of linear dependence between temperature and the rate constant, the time-temperature function becomes the traditional maturity function.

Keywords:Age-strength relation: compressive strength, concretes; mortars (material); temperature.

---

10. CARLSSON, M., Eeg, I.R. and JAHREN, P., A/S Scancem, Slimmestad, Norway, "Experience from use of break-off tester". In Situ / Nondestructive Testing of Concrete, SP-82,Amer.Concr.Inst.1984,pp.277-292.

A discussion is presented advocatig the use of in-situ testing of concrete and a brief description is given of the "Break-off" method. Some data are presented from an experimental investigation of"Break-off" testing applied to slip-formed concrete. Some consideration is given to its role as the test in concrete construction in developing countries and as a means to improve testing efficiency in the pre-cast and pre-stressed concrete industries are considered. Relative cost and time requirements are compared for break-off testing versus conventional laboratory testing. The authors consider that in-situ testing and the break-off method in particular will be used increasingly.

Keywords: Break-off method; concrete testing; in-situ testing; slip-formed concrete; tensile strength.

---

11. CONCRETE, "Specialized concrete evaluation and testing". Concrete Construction, V.20, No.12. Dec.1984. pp. 1097-1100.

Present problematic situations in concrete construction practices and the specialized testing services needed to remedy the particular problem. Standard methods for conducting teste used to evaluate concrete are discussed, including rebound, pullout, load testing,petrography,etc. A table listing some nondestructive test appolications is provided.

Keywords: Evaluation; hardened concretes; nondestructive tests; penetration tests; petrography; probes; pullout tests; shotcrete; standards; test eqipment; tests.

---

12. DAHL-JORGENSON, E. and JOHANSEN, R., Norwegian Institute of Technology, Trondheim, Norway, "General and specialized use of the break-off concrete strength testing method". In Situ / Nondestructive Testing of Concrete, SP-82, Amer. Concrete Inst., 1984, pp.293-308.

A reliable in-situ testing method such as break-off provides a more accurate estimate of the concrete strength of the structure then site-cured and laboratory-cured standard specimens. Considerable discrepancy was observed between strength measured in the structure and on separate specimens cast from the same mix. The test method also proved to be useful when testing bonding strength of concrete overlays and epoxy coating to concrete.

Keywords: Break-off method; concrete strength; epoxy coating bond; in-situ concrete strength; laboratory-cured test specimens;overlay bonding strength.

---

13. DORF, V.A. and ROMANCHUNK, V.E., "Determination of cement content in a concrete mix by a conductance measuring method"(in Russian). Beton i Zhelezobeton (Moscow), No.2,1984,pp.13-14.

A new physicochemical method to determine cement in concrete presented. The procedure used to apply this conductance measuring method,which takes into account electrolytes providing [illegible] the liquid phase of electrical conduction, is also discussed.When mixing cement and water, electrolytes are formed during hydration. The electrical resistance depends on a measure of the content of the cement.

Keywords: Cement content; conductivity; electrical properties; measuring instruments.

---

14. FACAOARU, L. Building Research Institute INCERC, Bucharest, Romania, "Achievements in nondestructive concrete strength estimation in Romania". In Situ / Nondestructive Testing of Concrete, SP-82, American Concrete Institute, 1984, pp.35-56.

This paper summarizes Romanian experience concerning in-situ concrete strength estimation by nondestructive methods.There are presented "classical" non-destructive methods such as ultrasonic pulse method and rebound method. The philosophy of transforming the measured property into concrete strength, taking into account concrete composition and maturity, is given. Details abount original developments of non-destructive for concrete strength estimation are also presented. Such developments are:

a) combined SONREB method based on pulse velocity and rebound index measurements,

b) sonic coring method,an immersion method using radial transducers, adapted for the inspection of deep foundations,

c) acoustic method by shock, a method based on the measurementof the natural period, for the quality control of precast units.

Keywords: Concrete strength; nondestructive testing; ultrasonic pulse velocity ; rebound; sonic methods; sonreb (combined method);coefficients of influence; natural period; rebound number; coring; shock.

---

15. HILLGER, W.and NEISECKE, J. "Ultrasonic pulse technique for the automatic non-destructive quality control of precast concrete components" (in German and English). Betonwerk und Fertigteil-Technik (Wiesbaden), V.50,No.11,Nov.1984,pp.769-773.

Ultrasonic measurements can be used to observe relative changes in concrete. Besides the pulse propagation time measurements commonly employed, amplitude or intensity measurements can be used with considerable advantage due to their great sensitivity.

Keywords: Measuring instruments; nondestructive tests; precast concrete; ultrasonic tests.

16. HÖNIG, A.,Brno Technical University Brno,Czechoslovakia,"Radiometric determination of the density of fresh shielding concrete in-situ". In-situ/ Nondestructive Testing of Concrete,SP-82, American Concrete Institute,1984,pp.603-618.

Radiometric determination of density and moisture of soils and building materials has been carried out successfully. Many types of instruments are not available for measurement on fresh concrete so that it is not possible to repair inhomogeneities, if any even before hardening. The paper describes an analog and a digital radiation density meter and their application in the inspection of concrete walls against radiation. Long-term and temperature stability, the measuring procedure, calibration of the instruments, biological shielding tests and the evaluation of the resuls are described.

Keywords: Radiation shielding; density of concrete; nondestructive testing; radiometry; portable gauge.

17. HULSHIZER , A.J.,EDGAR, M.A., DANIELS,R.E.,SUMINSBY,J.D. and MYERS, G.E., United Engineers and Constructors Inc.,Philadelphia, PA, U.S.A.,"Maturity concept proves effective in reducing form removal time and winter curing cost".In-situ / Nondestructive Testing of Concrete, SP-82, American Concrete Institute,1984,pp.351-376.

The Maturity Method for predicting in-situ concrete strength was evaluated under field conditions to establish it as a dependable, practical approach for the Seabrook work. Based on the test results the Maturity Method, utilizing elektronic Maturity Meters, was utilized to determine concrete strengths to enable tunnel arch forms to be safely removed in 12 to 14 hours.

Keywords: Cold weather curing; concrete; early strength; estimates; form removal; in-situ strength; maturity method; nondestructive testing; temperature history; Windsor Probes; young concrete strength.

18. JAPAN,"Transactions of the Japan Concrete Institute". Tokyo,V.6, 1984, 782 pp.

Of the 285 research papers published in Japanese,96 of the papers with English translations were accepted. Topics covered include materials, construction, deterioration,durability, strength,deformation,durability, strength, deformation of concrete, shear,torsion,and bond, structural behavior and analysis, ductility of structural members, and strengthening and repair.

Keywords: Alkali-aggregate reactions; bleeding (concrete);carbonation; compressive strength; concrete products; corrosion; cracking (fracturing); crushed concrete; deterioration;drying; durability; fatigue tests; fiber reinforced concretes; freeze-thaw durability; hardened concretes; mechanical properties; moisture; permeability; petrography; physical properties.

---

19. KEILLER, A.P., Cement and Concrete Association,Slough, England,"An investigation of the effects of test procedure and curing history on the measured strength of concrete".In Situ /Nondestructive Testing of Concrete, SP-82. American Concrete Institute, 1984,pp.441-458.

Concrete is usually specified in terms of the strength of standard specimens (normally cylinders or cubes) which are cast from samples of the fresh concrete. If the concrete in a structure is to be investigated using core tests, an understanding of the factors which influence the measured strength of a core together with a knowledge of the relationship between the strength of standard specimens and the strength of concrete in structures are required.

Keywords: Concrete; compressive strength; cores; cubes; core diameter; core orientation; curing conditions; strength relationships.

---

20. KHOO, L.M.,Singapore Institute of Standards and Industrical Research, Singapore, "Pullout technique - an additional tool for in-situ concrete strength determination". In Situ /Nondestructive Testing of Concrete, SP-82. American Concrete Institute, 1984,pp. 143-159.

In essence, a pullout test consists of measuring the force required to pull out a specially shaped insert whose enlarged end has been cast into the concrete. in this investigation, pullout tests were perfomed on 600 mm cubical concrete blocks. Compression strength tests were conducted on standard 150 mm cubes and also on Ø 100 x 200 mm cores drilled from the 600 mm blocks. Statistical analysis of the test data shows that there is a good correlation between the pullout strength and the corresponding compressive strength of cubes and cores.

Keywords: Compressive strength; concrete strength; in-situ nondestructive test; pullout test; quality control; statistical analysis.

---

21. DI LEO,A., PASCALE,G. and VIOLA,E., University of Bologna, Italy, "Core sampling size in N.D.T. of concrete structures". In Situ /Nondestructive Testing of Concrete, SP-82, American Concrete Institute, 1984, pp.459-477.

In this paper a procedure aimed, to assess the charakteristic value of actual compressive strength of in-situ concrete, is presented. The experimental values obtained from cores can be utilized to modify the characteristic value of estimated strength:

a) by means of an appropriate correcting coefficient;
b) statistically through the Bayesian approach, according to which the mean value of the actual strength is considered as a random variable. Consequently, its characteristic value also becomes a random variable.

Keywords: Concrete; strength; nondestructive testing; core testing; statistical analysis.

---

22. LONG, A.E., Queens University and MURRAY, A.McC.,Department of the Enviromment, Belfast, N.Ireland, "The "Pull-Off" partially desructive test for concrete". In Situ /Nondestructive Testing of Concrete, ACI SP-82,1984,pp.327-350.

A wide range of approaches are available for estimating the strength of in-situ concrete and these include indirect methods such as cube or cy - linder testing, nondesructive methods and the more recently partially destructive tests. In the latter category the pull-off test involves bonding a circular steel probe to the concrete surface using an epoxy resin adhesive which is stronger than concrete in tension. By measuring the load required to cause a tensile failure in the concrete the equivalent compressive strength can be estimated by using an appropriate calibration graph.

Keywords: Bond to concrete surface; calibration graph; concrete strength; cube test; cylinder test; epoxy resin bond; partially destructive test; pull-off test; tensile strength.

---

23. MALHOTRA, V.M.,CANMET, Ottawa, Canada, "In-situ nondenstructive testing of concrete - a global review"; SP-82. American Concrete Institute, 1984,pp.1-16.

During the past 40 years in-situ nondestructive testing of concrete has achieved increasing acceptance for the evaluation of existing concrete structures with regard to their uniformity, durability and other properties. The methods discussed for estimating concrete strength include surface hardness and penetration resistance tests,pullout, ultrasonic pulse velocity, break-off, combined methods, and maturity techniques.The tests reviewed for determining properties other than strength include magnetic, electrical, radioactive, pulse echo, radar, microwave absorption, acoustic emission, nuclear and infrared thermography.

Keywords: Concrete; compressive strength; break-off tests; penetration resistance test; pullout tests; surface hardness tests; ultrasonic pulse velocity; combined methods; maturity techniques; acoustic emission techniques; electrical, magnetic, nuclear, radioactive methods: infrared technique; pulse echo, radar, thermographic methods.

---

24. MLAKAR, P.F., WALKER, R.E, SULLIVAN,B.R. and CHIARITO,V.P.,Waterways Experiment Station, Vicksburg, MS, U.S.A., "Acoustic emission behavior of concrete". In Situ /Nondestructive Testing of Concrete, SP-82 ACI, 1984,pp.619-637.

The acoustic emissions of various concrete specimens under different loadings are studied. First, six monotonic and six cyclic load compression tests on 6 by 12-in. cylindrical concrete specimens were monitored for acoustic emission. Fundamental data were collected and analyzed and the Kaiser effect was observed The data are presented as counts versus events to aid in the identification of source characteristics. Next, one multiaxial load (compression and tension) test was monitored. The slope of the counts-versus events curve for this primarily tension test differed from those of the curves for the compression test. This difference suggests that the source characteristics of concrete acoustic emissions can be empirically separated and identified.

Keywords: Automatic emission; concrete; specimens; biaxial stress; Kaiser effect; reinforced concrete conduits.

---

25. MIKULIC,D., UKRAINCIK,V. and BALABANOVIC,G.,"Two-grade method to evaluate pressure stiffness of concrete in structure"(in Slavic). Nase Gradevinarstvo (Belgrade),V.38.No.5,1984,pp.8-13.

A testing method for quality approval of concrete's structural qualities is offered for use in situations where proper quality control may not exist. This testing method defines pressure stiffness by a destructive method or one of the nondestructive methods. The definitions of reliability for a given testing method are discussed, including the number of required checkpoints, measurements, and criteria necessary to achieve quality assurance, and the role of economic factors in testing. A quality-control method combining features of destructive and nondestructive testing is presented.

Keywords: Nondestructive tests; quality control; stiffness; structural analysis; tests.

---

26. NEWMAN,K., European Ready Mixed Concrete Association, Shepperton, England, "The ready mixed concrete producer's view of in-situ NDT". In Situ /Nondestructive Testing of Concrete, ACI SP-82,1984,pp.479-499.

Few concrete engineers appear to understand the relevance and meaning of the results of in-situ/NDT tests. These methods measure concrete properties in the actual structure (i.e."real-crete") which engineers should be interested in, whereas they still place undue emphasis on the results from standard tests (i.e."labcrete").

The respective responsibilities of the ready mixed concrete producer and contractor are defined. Recommendations are made for differentiating between "lab-crete" and "real-crete" by providing guidance on the assessment of concrete strength in existing structures, and for specifying the required concrete properties in terms of the "lab-crete" compressive strength.

Keywords: Concrete strength; in-situ tests; NDT methods; lab-crete; real-crete (in structure); ready-mixed concrete; standard tests,

---

27. NDT,"Developments in non-destructive testing" (in French). Publication Technique No.72, Centre d'Etudes et de Recherches de l'Industrie du Beton Manufacture, Epernow, Sept.1984,34pp.

This report describes the different nondestructive testing methods while taking into account the properties of concrete and indicates the methods with some technical-commercial interest. Practical examples illustrate the possible applications of these methods, more particulary in estimating the resistance of concrete with tests at early age. The advantages of nondestructive testing versus the traditional breaking tests are then highlighted.

Keywords: Costs; nondestructive tests; tests.

---

28. OKADA,K.,KOBAYASHI,K. and MIYAGAWA,T.,Kyoto University,Kyoto,Japan, "Corrosion monitoring method of reinforcing steel in off-shore concrete structures". In Situ /Nondestructive Testing of Concrete, ACI, SP-82, 1984,pp.703-720.

The half-cell potential method can be used assess the progress of reinforcing steel corrosion. The numerical model analisis proposed in this paper can estimate the macro cell corrosion rate and its distribution along the length of reinforcing steel. Applicability of this method, however, is limited because of disturbance of electrical circuit caused by water on the concrete surface. The polarization resistance method can also estimate the corrosion rate of steel in concrete structures e posed to various environmental conditions. The results indicate that both monitoring methods make up for the disadvantages of each other and can be utilized as the corrosion monitoring techniques.

Keywords: Corrosion monitoring; environmental condition; half cell potential; polarization resistance; macro cell; micro cell; chloride corrosion; maintenance; repair.

---

29. PARSONS, T.J.,National Institute for Occupational Safety and Health, Morgantown, WV, and NAIK,T.R., University of Wisconsin-Milwaukee,WI, U.S.A., "Early-age concrete strength determination by pullout testing and maturity".In Situ /Nondestructive Testing of Concrete, ACI, SP-82, 1984, pp.177-199.

This paper reports results of an investigation of the use of pullout testing and the maturity method to predict the early age strength of concrete. Cylinder compression and pullout tests were performed on specimens at ages ranging from 12 to 168 hours (7 days). Regression equations for cylinder strength and maturity and pullout force and maturity are developed where the maturity is modified by changing the datum temperature from -10 C to 0 C to improve the predictive capabilities.

Keywords: Compressive strength; concrete; datum temperature; early age strength; maturity technique; pullout test; regression equation; strength testing; water-cement ratio.

---

30. PRAKASH RAO,D.S.,"Some pitfalls in the ultrasonic pulse velocity method of testing hardened concrete". Indian Concrete Journal (Bombay),V.58,No.10,Oct.1984,pp.254-257,273.

Ultrasonic pulse velocity (UPV) method of testing hardened concrete is extremely simple and large amounts of data can be collected in a short time. However, interpretation of results is not always easy due to the large number of factors that affect the pulse velocity. The method and some of the problems in assessing the data from tests on concrete are discussed. It is emphasized that like most nondestructive techniques of testing hardened concrete UPV can only supplement engineering judgment and cannot substitute for it.

Keywords: Cracking (fracturing); hardened concretes; nondestructive tests; strength; ultrasonic tests.

---

31. PRAKASH RAO,D.S., TAMHANKAR,M.G.,and SHARMA,S.P., "Literature survey of in situ testing of concrete bridges". RILEM, Materials and Structures, Research and Testing (Paris), V.16. No96, 1924,pp.457-466.

In situ testing of bridges demands considerable expertise and entails heavy expenditure. The tests may vary from merely routine tests to diagnostic tests to locate the source of distress in the structure. This paper discusses briefly the objectives of the tests and the instrumentation usually employed. Salient features of the tests on concrete bridge superstructures reported in the last decade are summarized. Discussion on the evaluation criteria and recommendations for further work are also included.

Keywords: Bridges (structures); dynamic tests; measuring instruments; nondestructive tests; static tests; superstructures; surveys.

---

32. REBIĆ, M.P.,Institute for Testing and Research in Materials and Structures, Ljubljana, Yugoslavia, "Distribution of critical and rupture loads and determination of the factor of crackability". In Situ /Nondestructive Testing of Concrete,ACI SP-82,1984,pp. 721-730.

During the compressive loading of 20 cm and 10 cm concrete cubes, acoustic emission (AE) and the ultrasonic pulse transit time were measured. The critical load (σ_c) at which the internal structure of the concrete begins to deteriorate is determined from the AE and transittime/σ diagrams. The ratio between σ_c and σ_r, the rupture load, is defined as the crackability factor $F = \sigma_c/\sigma_r$. This factor increases from zero (for ideally ductile materials) towards a value of 1.0 (for completely brittle materials). From the tests described it follows that the factor F has practically the same value, whether it is determined from AE or ultrasonic neasurements.

Keywords: Acoustic emission; concrete; crackability factor; critical load; pulse transit time; rupture load; ultrasonic pulse velocity.

---

33. RILEM, "Rilem international symposium on long-term observation of concrete structures" (Budapest, Sept. 1984), V.1 (in English and French). Institute for Quality Control in Buildings (1502 Budapest, Pf.69, Hungary), 1984, 444 pp.

Presents an interchange of information on the longterm observation of concrete structures. Volume 1 reports on experimental observation methods and the development and use of equipment for the theoretical prediction of the service life of concrete structures.The symposium is intended for researchers and practicing engineers with an interest in the use of longterm observation results to verify their designs.

Keywords: Bridges (structures); cracking (fracturing); deformation; loads (forces); long-time study; nondestructive tests; prestressed concrete; reinforced concrete; repairs; research;safety; tests.

---

34. ROPER, H.,BAWEJA, D. and KIRKBY,G, University of Sydney, Australia, "Towards a quantitative measure of durability of concrete structural members". In Situ /Nondestructive Testing of Concrete, ACI SP-82, 1984.pp.639-658.

Brief consideration is given to the uses of a quantitative measure of durability of concrete structural members. A classification scheme of structures, elements, causes and effects is reviewed by the use of examples. Any quantitative measure of durability of in-situ structural members must be based on data gathered using nondestructive test methods.For any phenomenon such as cracking, corrosion or spalling which influences durability, three factors must be considered, viz. a method of measurement of the phenomenon, the intensity of the phenomenon, and its distribution over the observed area.

Keywords: Durability of concrete; classification of structures; quantitative measurements, NDT methods; optical analysis.

---

35. SAMARIN, A., Sydney,Australia and DHIR, R.K., Dundee, Scotland, "Determination of in-situ concrete strength: rapidly and confidently by nondestructive testing".In Situ /Nondestructive Testing of Concrete,ACI SP-82, 1984,pp.77-94.

The determination of concrete properties could only be approximate, given the varied nature of concrete due to its intrinsic make-up and workmanship, as well as such factors as enviromental conditions and age. The use of nondestructive testing of concrete should be assessed against this background. A method combining the rebound hammer and pulse velocity readings is explained. From the studies undertaken in Australia and Scotland it appear that the combined method approach could help to further increase the confidence in estimatig the strength of in-situ concrete.

Keywords: In-situ concrete strength; nondestructive tests; Schmidt test hammer; ultrasonic pulse velocity; combined method application.

---

36. SCHICKERT, G. "Critical reflections on nondestructive testing of concrete", Materials and Structures, Research and Testing (Rilem, Paris), V.17,No.99, May-June 1984,pp.217-223.

Sclerometer tests, the ultrasonic pulse velocity method, the acoustic emmission technique and combined nondestructive methods for testing concrete properties are discussed. Examples and test results obtained by investigations with rigid and flexible loading platens show the efficiency of additional nondestructive testing. Finally, the nondestructive testing methods under consideration as independent testing tools are critically analyzed under several aspects.

Keywords: Concretes; nondestructive tests; ultrasonic tests.

---

37. STURRUP, V.R.,Consultant, Etobicoke, Ont., VECCHIO,F.J.,and CARATIN, H., Ontario Hydro, Toronto, Ont., Canada,"Pulse velocity as a measure of concrete compressive strength". In Situ /Nondestructive Testing of Concrete, ACI SP-82,1984,pp.201-227.

Relationships can be established for concrete between the pulse velocity and concrete strength, but they are influenced by many factors. Of particular singnificance are the proportions and composition of concrete mix components, age,curing conditions and moisture content of the concrete. A relationship established at early ages is not applicable as concrete matures. The relationship betveen pulse velocity and concrete strength can be confused by cracks, voids or other discontinuities in the concrete.

Keywords: Admixtures; aggregates; composition (concrete); cracks; density; freezing and thawing; moisture content; pulse velocity; strength; temperature (concrete); voids.

---

38. SWAMY, R.N.,University of Sheffield, England, and AL-HAMED, A.H., National Centre for Construction Laboratories Baghdad, Iraq,"Evaluation of small diameter core tests to determine in-situ strength of concrete". In Situ /Nondestructive Testing of Concrete,ACI SP-82, 411-440,pp.

This paper presents tests on 50 mm diameter cores to evaluate their use to determine in situ concrete strength. The cores, with height to diameter ratios of 1 and 2, were drilled vertically from slabs which were cured in an uncontrolled internal environment to simulate conditions in practice. The variables investigated include different concrete strength levels, mix proportions, age, size and type of coarse aggregate and concrete type - i.e., normal and lightweight. The core strength results are related to core and cube pulse velocity and Windsor probe test results.

Keywords: Concrete; concrete strength; drilled cores; in-situ concrete strength; pulse velocity, Windsor probe test.

---

39. SWAMY, R.N.,University of Sheffield, England and AL-HAMED, A.H., National Concrete for Construction Laboratories, Baghdad, Iraq, " The use of pulse velocity measurements to evaluate in-situ concrete strength". In Situ /Nondestructive Testing of Concrete, ACI SP-82,1984,pp. 247-276.

The paste efficiency concept based on the pulse velocity difference between a control specimen and the concrete in strength and hence in situ concrete strength. This paper presents extensive test evidence to substantiate the validity of the paste efficiency principle.It is shown that the use of air-dried cubes (representing in-situ concrete) produces consistent results.

Keywords: Air-dried cube strength; concrete strength;drilled core strength in-situ strength of concrete; "k" factor; paste efficiency concept; pulse velocity.

---

40. TAKABAYASHI,T., Yoshino Rika Kogyo Co.Ltd.,Tokyo, and ISHIDA,H., Shibaura Institute of Technology, Shibaura, Japan,"Measurement of thickness of concrete structures".In Situ /Nondestructive Testing of Concrete, ACI SP-82,1984,pp.659-671.

This paper describes a method of measuring the thickness of concrete pavement and concrete structural members. A particular feature of this method involves the combined use of the ultrasonic pulse and resonance methods to compute the thickness of concrete by measuring the pulse velocity and resonant frequency of concrete.

Keywords: Concrete; pavement thickness; NDT methods; resonant frequency; thickness of concrete; ultrasonic pulse velocity method.

---

41. TAMURA, H. and YOSHIDA, M., General Building Research Corp., Osaka-fu, Japan."Nondestructive method of detectig steel corrosion in concrete". In Situ /Nondestructive Testing of Concrete, ACI SP-82, 1984,pp.689-702.

This paper presents a new nondestructive detecting method of corrosion of reinforcing steel in concrete . The state of corrosion of steel can be electrochemically estimated by using not only natural potential,but also polarization and electrolyte resistance. These th~~e~~ree kinds of electrochemical values can be measured with a polarization resistance meter and a two-electrode probe set on the surface of concrete above any measuring point of steel.

Keywords: NDT method;corrosion rate; corrosion current; steel; reinforced concrete; electrochemical; natural potential; polarization resistance; electrolyte resistance; electric circuit.

---

42. TANIGAWA, Y., BABA,K. and MORI, H., Mie University, Kamihamacho, Japan, "Estimation of concrete strength by combined nondestructive testing method". In Situ /Nondestructive Testing of Concrete,ACI SP-82,1984,pp.57-76.

The purpose of the present paper is to obtain a practical expression for estimating the compressive strength of concrete,combining rebound number with ultrasonic pulse velocity. Experimental investigations were carried out to examine the effects of factors such as water cement ratio, the maximum size and volume fraction of coarse aggregate, the curing condition and age of concrete. Accuracies of the prediction expressed in various types of empirical formulae are examined by multiple regression analysis, and practical equations for estimating the concrete strength are proposed.

Keywords: Combined NDT method; compressive strength; regression analysis; Schmidt test hammer technique; ultrasonic pulse velocity method.

---

43. UOMOTO, T. and KOBAYASHI, K., University of Tokyo, Japan,"In-situ test to determine fiber content of steel-fiber-reinforced concrete by electro-magnetic method". In Situ /Nondestructive Testing of Concrete, ACI SP-82,1984,pp.673-688.

Determination of the fiber content of SFRC can be accomplished by using techniques such as X-ray image analysis, seperation by washout analysis, and an electro-magnetic method. The special electro-magnetic method described herein is not only applicable to hardened concrete but also to fresh concrete. Measurement of fiber content can be done within a few minutes. This method has been introduced as a standard test for SFRC in Japan.

Keywords: In-situ test; fiber content; electro-magnetic method; steel fiber reinforced concrete;fresh concrete; hardened concrete; electro-magnetic attachment.

---

44. U.S.S.R. "Ultrasonic method of frost-resistance determination" (from Russian).USSR State Committee for Constructions, GOST 26134-84 (Moscow), 1984, 15 pp. Available from Cembureau.

Keywords: Density; freeze-thaw durability; lightweight concretes;specifications; standards; ultrasonic tests.

---

45. VOGT,W.L. and BEIZAI,V., MRA/Materials Engineers Inc., Houston, TX, and DILLY,R.L., University of Houston, TX, U.S.A.,"In-situ pullout strength of concrete with inserts embedded by Finger placing". In Situ /Nondestructive Testing of Concrete, ACI SP-82,1984, pp.161-175.

Early strength information may be a useful quideline for form removal, stressing or reshoring.This technique of embedding pullout inserts to determine the strength of hardened concrete was used during the construction of a box culvert requiring approximately 11,500 m^3 of concrete. Thirty locations on the structure were tested to determine the force required to extract embedded inserts at ages of two, four, and seven days. Generally, higher pullout forces were required to extract inserts as the concrete matured. Currently no criteria exist for evaluating the pullout test results; however, the data obtained throughout this study appears to be normally distributed at early ages. The standard deviation and within test variation values are higher than expected.

Keywords: Concrete strength; early strength; evaluating pullout test results; "finger placing" technique; form removal guideline; In-situ concrete strength; pullout inserts; reshoring; stressing.

---

46. WELSH, J.P.,editor,"Innovative cement grouting". Special Publication No.83, American Concrete Institute, Detroit, 1984,184 pp., $ 31.95,($ 24.95 to ACI members).

This publication includes a selection of the papers presented at the two-part technical session,"Innovative Materials and Techniques in Cement Grouting", during the 1983 ACI Fall Convention in Kansas City.Both academic research papers and construction-oriented papers are contained in the volume. The academic papers discuss potential new uses of existing materials, current research into a new nondestructive testing method, and properties of cement grouts.

Keywords: Betonite; cements; cold weather construction; concrete dams; fineness; foundations; grout; grouting; mix proportioning; nondestructive tests; piers; plasticizers; post-tensioning; pressure grouting; prestressing; repairs; seepage; shrinkage; silica; tunnel linings;tunnels; volume change; workability.

---

47. WHITING, D., Construction Technology Laboratories, Skokie, IL., U.S.A., "In-situ measurement of the permeability of concrete to chloride ions". In Situ /Nondestructive Testing of Concrete,ACI SP-82,1984,pp.501-524.

An electronic device and test procedure which can be used to rapidly assess the permeability of various types of concrete to chloride ions is described. The method consists of monitoring the amount of electrical current passed thørough a test area on a concrete slab when a potential difference of 80 Vdc is maintained across the specimen for a period of six hours. Chloride ions are forced to migrate out of a sodium chloride solution subjected to a negative charge through the concrete towards reinforcing steel maintained at a positive potential. The method has been found to give a good correlation with long-term ponding data on companion concrete slabs.

Keywords: Bridge decks; chlorides; latex; nondestructive tests; on-site tests; overlays; permeability; polymer concrete.

---

48. WINSLOW, D.N.,"Rockwell hardness test for concrete." Cement, Concrete, and Aggregates, V.6,No.2, Winter 1984,pp.137-141.

The standard superficial Rockwell 15Y hardness test is adapted for use on concrete. Hardness measurements are made on the mortar regions between the coarse aggregate pieces. A correlation between this hardness and the concrete's compressive strength is developed. Various effects of specimen preparation and size are discussed, as are the statistics of the test.

Keywords: Compressive strength; concretes; hardness; measurement;tests.

---

49. YENER, M. and CHEN, W.F.,"In-place strength of concrete and pullout tests." Cement, Concrete, and Aggregates, V.6,No.2, Winter 1984,pp.90-99.

The current status of in-place strength evaluation of concrete is discussed. A literature survey regarding the controversy surrounding the assessment of concrete strength through field-cast laboratory-cured cylinder tests is presented. Inconsistencies associated with the drilling and testing of cores for determining in-place concrete strength are pointed out. On the basis of these arguments, the necessity of developing alternative nondestructive test procedures is emphasized. This is followed by a detailed discussion on the status of the pullout test method as a measure of compressive strength of in-place concrete, which appears to be a potentially feasible nondestructive test procedure.

Keywords: compressive strength; concretes; flexural strength; nondestructive tests; pullout tests; reviews.

---

50. ZUBKOV, V.A., "Ultrasonic sensors to control concrete strength", (in Russian) . Beton i Zhelezobeton (Moscow), No.1,1984,pp.33-34.

The ultrasonic pulse method is largely used to control reinforced concrete structure strength. Various types of sensors are described and compared as well as the different procedures to use them.

Keywords: Reinforced concrete; strength; ultrasonic tests.

1985

51. AKASHI, T. and AMASAKI,S.,"State-of-the-art on nondestructive testing of concrete" (in Japanese). Concrete Journal (Tokyo), V.23,No.12,Dec.1985,pp.11-20.

There are many methods for nondestructive testing of concrete. This paper describes the available nondestructive tests for evaluation of existing concrete structures with regard to their strength and other properties,and the future of nondestructive tests. The methods discussed include surface hardness and peneration tests, ultrasonic pulse velocity, break-off, pullout, and combined methods.

Keywords: Compressive strength; cracking (fracturing); nondestructive tests; pullout tests; penetration tests; shotcrete; ultrasonic tests.

---

52. BAKER, A.F.,"Testing concrete quality" Concrete (London),V.19,No. 12, Dec. 1985,pp.19-20.

Discusses permeability testing and detailed microscopic examination. Testing the quality of concrete as well as its strength and cement content is especially helphful in light of the evidence of deficient concrete buildings over the past 25 years.Permeability tests are very sensistive to water-cement ratio and effectiveness of curing, both factors that contribute to long-term durability. Microscopic examination of concrete can identify such problems as cracking and creep by investigating aggregate grading and reactivity and the presence of unhydrated cement and lime.

Keywords: Concretes; microscopy; permeability; quality control; sampling strength; tests; water-cement ratio; x-ray analysis.

---

53. BERTHELOT,J.M. and ROBERT,J.L.,"Application of acoustic emission to mechanisms of concrete damage" (French). Bulletin de Liaison des Laboratoires des Ponts et Chaussees (Paris),N. 140,Nov.-Dec. 1985, pp. 101-111.

The technique of acoustic emission has been used to follow the evolution of concrete damage in various tests. Using a technique of triangulation, acoustic emission makes it possible to localize the damage in the course of a test. The damage is progressive along the crack and during a test, acoustic emission makes it possible to follow the evolution of various crack zones of damage in samples of concrete.

Keywords: Acoustic emissions; cracking (fracturing); damage; tests.

---

54. CHUNG, H.-W. and LAW, K.-S., "Assessing fire damage of concrete by the ultrasonic pulse technique". Cement, Concrete, and Aggregates, V.7, NO.2, 1985, pp. 84-88.

When a concrete member is exposed to fire, the exterior of the member is heated drastically while the interior remains at a relatively low temperature. It is most useful to the engineer to know the extent of damage for estimating repair work. Thickness of the damaged layer can be expediently assessed by measuring the velocity of ultrasonic pulses along the surface. The accuracy of this technique has been assessed with a series of tests in which the concrete was heated to various temperatures; results indicate that the technique is relatively accurate.

Keywords: Concretes; fire tests; nondestructive tests; thermal gradient; ultrasonic tests.

---

55. CROVETTI, J.A. and DARTER, M.I.,"Void detection for jointed concrete pavements". Transportation Research Record No.1041,Transportation Research Board, Washington, D.C.,1985,pp.59-68.

Procedures for the detection of voids or loss of support under jointed concrete pavements by using nondestructive testing measurements are presented. A rapid field-applicable procedure is presented to quickly determine the presence of voids by analysis of the load and deflection response at slab-corners. A more detailed method is presented in which deflection measurements from center slab and corner locations are used to locate and determine the approximate size of any existing voids.

Keywords: Concrete pavements; concrete slabs; deflection;finite element method; grout; joint sealers; load transfer; nondestructive tests;voids.

---

56. CZIESIELSKI, E., Techn.Univ.Berlin, Germany."Aufgabengebiete der ZfP im Hochbau", (Application of NDT in Building Construction). Proc. ZfP Bau-Symposium, Berlin, Oct.2/3, 1985,pp.59-67.

The nondestructive testing (NDT) methods are being used for the following purposes:

1) To determine the strength and carrying capacity of the building construction.
2) To test moisture content of structural members and materials.
3) To measure the heat transfer and insulation properties.
4) To determine acoustical properties of the building.
5) To observe chemical changes,location of begin of corrosion in rebars.
6) To observe biological changes in wooden parts.
7) Longtime building durability observation.

Keywords: NDT; assurance of strength; guaranty of quality requirements.

57. DI MAIO, A.A., TRAVERSA,L.P. and GIOVAMBATTISTA,A.,"Nondestructive combined methods applied to structural concrete members".Cement, and Aggregates, ASTM,V.7,No.2, 1985,pp.89-94.

Strength evaluation of structural members has been done with such nondestructive methods as ultrasonic pulse velocity, hammer rebound, and lokalized pressure, either individually or by combining methods. The effects of the mineralogical composition of the coarse aggregate, moisture content, and age of concrete on pulse velocity and rebound number is reported. Standard cylindrical specimens cured at 100 percent relative hummidity were tested for compressive strength. Regression equations thus obtained were used to estimate the in-situ compressive strength of reinforced prisms measuring 0.15 x 0.15 x 1.00 m. The prediction error is calculated from the comparison of the estimated strength and the strength determined on drilled cores.

Keywords: Compression tests; compressive strength; cores; nondestructive tests; specimens; structural members; ultrasonic tests.

---

58. DUFAY, J.C. and PICCARDI, J.,"Scorpion: The first high-energy televised radioscopy system for the non-destructive control of prestressed concrete civil engineering structures",(in French). Bulletin de Liaison des Laboratories des Ponts et Chaussees (Paris) No.139,Sept.-Oct. 1985,pp.77-83.

The Blois Regional Laboratory of the LPC specializes in the nondestructive control of hydraulic concrete structures using x-rays or gamma rays. The laboratory has researched televised radioscopy and the method is now operational. The method was developed in two stages. The first stage led to the development of an instrument to convert x-rays or gamma ray photons into light photons. This convertor makes it possible to obtain, in place of radiographic images, images recorded by a highly sensitive camera and displayed on a television monitor. In the second stage a 250 kg linear accelerator was built.It allows investigations to be made to a thickness of 80 cm of concrete using radioscopy, and to 1.2 m using radiography, with exsposure times not exceeding 30 minutes.

Keywords: Nondestructive tests; prestressed concrete; radiography; x-ray analysis.

---

59. DOBMANN, G. (Fraunhofer Institut für ZfP, Saarbrücken),"Bestimmung der Überdeckung und des Durchmessers der Bewehrung mit Magnetischen Methoden",(Evaluation of the Concrete Cover and Rebar Diameter by Magnetic Methods). Proceedings of ZfP Bau-Symposium, Berlin (Germany) Oct.2/3, 1985,pp.318-325.

The amplitud lines of normal components from the magnetic line fields of the magnetized rebars provide correlation for the evaluation of rebar diameter and concrete cover thickness. This paper provides the basic information on the development of this NDT method.

Keywords: Concrete; magnetic test method; magnetic field lines; NDT method; rebar concrete cover.

---

60. "Evaluation techniques ease restoration choices". Roads & Bridges, V.23,No.7, July 1985, pp.40-42.

Confident restoration or reconstruction of a damaged or deteriorated pavement can proceed only when dependable information on pavement structure is available. Quality control involves all participants in the paving process from the design engineer to the finisher, and requires up-to-date equipment, well-trained operators, and current design.The increased use of nondestructive testing allows state higway departments to attack the multifaceted problem of concrete pavement distress by attending to the causes, rather than the symptoms, of failure to repair existing or prevent future damage .

Keywords: Concrete construction; concrete pavements; highways; nondestructive tests; quality control; reinforced concrete; renovating; repairs; resurfacing; roads; test equipment; tests.

---

61. HANNANT, D.J. and KEATING, J.,"Equipment for assessing the development of structure in fresh cement pastes by the measurement of shear modulus". Cement and Concrete Research,V.15,No.4,July 1985, pp.605-612.

A technique is described for the nondestructive measurement of the shear modulus of fresh cement pastes or of other fragile suspensions. By using this technique, a quantitative assessment can be made of the changing physical properties of the delicate structures which develop in hydrating cement pastes or other suspensions from about 10 minutes after mixing with water until after initial set or alternatively for much longer periods provided that the test material can ultimately be washed out of the test container.

Keywords: Cement pastes; hydration; measuring instruments; nondestructive tests; shear modulus.

---

62. HEIDT, H. & GOEBBELS, J.(BAM Berlin),"Radiometrie und Rechnergestützte Durchstrahlungsverfahren für die Erkennung von Betonschäden", (Computer Aided Radiometric Method for Investigation of Defects in Concrete). Procedings of ZfP Bau-Symposium, Berlin, (Germany),Oct. 2/3,1985, pp.170-177.

For the nondestructive investigation of defects in concrete a number of computer aided radiographic methods are available. By digital image processing of radiographs additional information can be gained.Computer axial tomography (CAT) provides a complete slice through the object with absorption or density values.

Keywords: Computer; concrete; concrete defects; NDT method; radiographic method; CAT; tomography.

63. HINDO, K.R. and BERGSTROM, W.R.,"Statistical evaluation of the in-place compressive strength of concrete".Concrete International: Design & Construction, V.7,No.2,Feb.1985,pp.44-48.

Considerable research effort has been directed toward developing reliable, nondestructive methods for testing the strength of concrete in place. These methods have created the need for a valid statistical analysis to evaluate test results with a prescribed level of confidence.However,ACI does not provide statistical analysis for evaluating compressive strength of in-place concrete. In view of this, it is timely that a statistical method be developed to properly evaluate the in-place test results of concrete.

Keywords: Acceptability; compressive strength; concretes; nondestructive tests; quality control; statistical analysis.

---

64. HOFFMAN,D. & NIESEL,K. (BAM, Berlin), "Möglichkeiten der Feuchtingkeitsmessung in Baustoffen",(Facilities of Measuring Moisture in Building Materials). Proceedings of ZfP Bau-Symposium, Berlin (Germany), Oct.2/3,1985,pp.248-256.

Different methods used for moisture determination in building materials are discussed. One of these, based on changes of the materials dielectrical constant, is discussed in details. One cannot get a quantitative mapping of the moisture distribution, but an approximate demarcation of zones with a moistening no more tolerable. This procedure has been approved in building practice as shown in an example. However, such tests should be carried out by an exspert.

Keywords: Concrete: moisture meters; electrical; nuclear; infrared; radiographical; chemical; termometrical; NDT; computer-tomographical; ultrasound pulse velocity.

---

65. HUNDT, J. & DANSMAN, J.(BAM, Berlin),"Einsatz der Endoskopie zum Nachweis von Schäden an Massivbauten" (The Use of Endoscopy to Determine the Damages in Massive Structures). Proceedings of ZfP Bau-Symposium, Berlin (Germany), Oct.2/3, 1985,pp.287-295.

For inspecting building components the visual observation is an important resort. Because of damages and other reasons it is often necessary to make hidden internal details visible. Endoscopes can fulfill such purposes, restricting the operations at the structural member to a small amount. For technical purposes we can use stiff and flexible system. In combination with other methods certain details can be cleared up.

Keywords: Concrete damages; endoscope pictures; drilled hole; videoendoscope

66. JAPAN, "Transactions of the Japan Concrete Institute", Tokyo, V. 7, 1985, 622 p.

The Transactions have been published in English every year since 1979. Research papers published in Japanese from the Japan Concrete Institute totalled 196 during the period considered for the 1985 Transactions. Of these, 17 were included in the Institute's monthly Concrete Journal from June 1983 thorough May 1985, and 179 appreared in the Procedings of the Annual JCI meeting held in June 1985. Only the papers with English translations were reviewed and 79 were acceped.

Keywords: Alkali aggregate reactions; cements; concrete construction; corrosion resistance; cracking (fracturing); crack width and spacing; curing; deterioration; dying shrinkage; durability; fatigne (materials); flexural strength; freeze-thaw durability; ligtweight concretes; permeability; portland cements; prestressed concrete; reinforced concrete; strength; structural members.

67. JENKINS,R.S. "Nondestructive testing - An evaluation tool". Concrete International: Design & Construction, V.7,No.2.Feb. 1985, pp.22-26.

The use of nondestructive test procedures to evaluate problems or failures of concrete materials can result in a certain amount of uncertanity in determining the in-place strength of the concrete. Although regression data can be analyzed for the best fit correlation, there is a rather large magnitude of uncertainty in the determined strength due to inherent variability in the test procedures. Nondestructive tests tilizing rebount hammer testing, penetration testing,or ultrasonic testing may allow a degree of uncertainty as great as 600 to 900 psi (4.1 to 6.2 MPa) in the strength determination.

Keywords: concretes; errors; evaluation impact hammer tests; nondestructive tests; peneration tests; ultrasonic tests.

68. JEVTIC,D.,"Analyses of effects of frost concrete built superplastifier additives"(in Yugoslavian). Nase Gradevinarstvo(Belgrade) V. 39, No.12.Dec.1985,pp.16-19.

Based on experimental results, the paper actually deals with the frost effects to concrete composition with superplasticizer additives based on melmente. There are five different concretes made that differ by water-cement factors (from 0.35 to 0.55),making them rigid, faintly plastic, and fluid. Samples of concrete were exsposed to effects of frost and aging for at least 7 days, in cycles 50 and 100. Hardness tests does not show a drop compared to concrete hardness tested under equivalent conditions. The experiments carried out with concrete by nondestructive methods by measuring speed ultrasound indicate the high compactness of all concretes.

Keywords: Freezing; hardeness; nondestructive tests; plasticizers; ultrasonic tests.

69. JUNGWIRTH, D. (Dyckerhoff & Widmann A.G. München),"Bedarf an Zerstörungsfreier Prüfung im Bauwesen aus der Sicht der Baupraxis" (NDT from the Point of View of Practical Construction).Proceedings ZfP Bau-Symposium, Berlin (Germany), Oct.2/3, 1985,pp.42-50.

There are three fields of application, where practical construction must have an interest in feasible N.D.T..These are:

a) execution of the construction work, e.g. observation of concrete strength attained at form removal, concrete prestressing time,etc;
b) quality control of cast concrete, or test samples;
c) maintenance of erected concrete structures, using different test methods to determine concrete defects.

Keywords: Concrete strength, density; moisture; rebar cover; location; corrosion; concrete defects; honey-combs; cracks, u-sonic pulse velocity; radiography; surface hardness.

---

70. KASAI,Y.,"Trends of concrete testing: Review of the testing methods adopted in the past 10 years" (in Japanese).Cement and Concrete (Tokyo), No.460, June 1985,pp.2-8.

The article presents the standards (mainly JIS) revised or newly adopted in Japan during the past 10 years in the following fields: tests relative to cement, aggregates, water, additives and admixtures, fresh concrete (w/c, unit-cement quantity; estimation of the concrete chloride content; workability); tests carried out during concrete setting and early stage hardening, and tests relative to the development of compressive strength; tests relative to fiber-reinforced concrete and structural concrete. Among the above-mentioned items, the paragraphs concerning aggregates, additives, and admixtures are particulary emphasized.Nevertheless, the whole article consists of an enumeration of details rather than in a comparative analysis of the advantages of each testing method.

Keywords: Admixtures; aggregates; cements; compressive strength; cracking (fracturing); durability; fresh concretes; hardening; reinforced concrete; standards; strength; tests; water; workability.

---

71. KEILLER, A.P.,"Assessing the strength of in-situ concrete: An investigation of test methods".Concrete International: Design & Construction, V.7,No.2,Feb.1985,pp.15-21.

A number of tests for assessing the strength of in-situ concrete have been developed in recent years. Although some of these tests cause minor damage to the concrete, they do not generally impair the load-carrying capacity of the structure and may, therefore, be thought of as nondestructive. Research was performed at the Cement and Concrete Association to compare and evaluate some of these test methods and to determine their usefulness in assessing the strength of concrete in structures.

Keywords: Compressive strength; concrete cores; nondestructive tests; probes; pullout tests.

---

72. KOROLEV,M.V.,et al.,"Portable instrument for ultrasonic control of concrete strength" (in Russian). Beton i Zhelezobeton (Moscow),No. 6, 1985,pp.31.

This UF-50MTS instrument, intended to control by ultrasounds concrete, silicate brick, and other building material strength, consists of a time-interval counter. It permits the use of through and surface sonic testing means. This light instrument is made of two electronic blocks-receiver and emitter.

Keywords: Concrete technology; silica; strength; ultrasonic tests.

---

73. KOSTRENCIC,Z., BJEGOVIC,D. and BALABANIC,G.,"Mathematical evaluation of the quality of repairs on concrete specimens".Cement, Concrete, and Aggregates,V.7,No.2,1985,pp.95-99.

It is possible to assess the efficiency of repairs on concrete and reinforced concrete structures by comparing ultrasound pulse velocities taken before and after the repairs are made. This paper illustrates two statistical methods: (1) comparing the velocities and using t-test, and (2) using the χ^2-test. The application of the former is good when individual repairs are considered; the latter is better when a greater number of repaired areas must be considered and the stability of an entire structure must be appraised. Both methods were applied to bridge prestressed beams,and the advantages of each are discussed.

Keywords: Concretes; maintenance; nondestructive tests; reinforced concrete repairs; ultrasonic tests.

---

74. KRASNOVSKY,B.M. et al.,"Ultrasonic method to control high-strength concretes" (in Russian). Beton i Zhelezobeton (Moscow),No.6,1985, pp. 27-28.

Tests were carried out to select a parameter characterizing concrete strength and establishing a relation between strength and concrete nonlinearity, measurement of which permits the determination of M500, and over, concrete strength directly in concrete products; this is very important to estimate their quality in the absence of taken-off samples and to reduce material consumption and labor expenditure necessary in other control methods.

Keywords: Concrete products; concrete technology; costs; highstrength concretes; quality control; strength; ultrasonic tests.

---

75. LALOUX,R. and ROBERT,J.-L., "Acoustic emission techniques applied to civil engineering" (in French). Bulletin des Liaison des Laboratoires des Ponts et Chaussees (Paris) NO.139, Sept.-Oct. 1985, pp. 93-98.

Acoustic emission is a phenomenon of creation and propagation of transitory elastic waves resulting from internal local micro-displacements in a material. The detection and analysis of these waves provide information on the physical mechanisms that generated them. Acoustic emission techniques have been employed to monitor structures in service , to detect failure of strands in prestressing cables and the cracking of concrete, and to study mechanisms of the cracking of concrete carried out on test samples in the laboratory. In the study of concrete cracking, acoustic emission has made it possible to define the dimensions of the damaged area of a sample subjected to tensile cracking tests. However, the different physical processes occurring during micro and macro cracking have not been distinguished.

Keywords: Crack propagation; cracking (fracturing);nondestructive tests; sonic tests (resonance); ultrasonic tests.

---

76. MALHOTRA, V.M.,"Testing early-age strength of concrete in-place". Concrete International: Design & Construction,V.7,No.4,Apr.1985, pp.39-41.

Discusses the need for tests to determine the earlyage strength and quality of concrete in-place. Currently available test methods and their advantages and limitations are examined.It is concluded that available in-place testing methods are adequate, although not perfect, to provide the needed information for safe form removal during construction.

Keywords: Age-strength relation; compressive strength; concrete construction; form removal; penetration tests; pullout tests; quality control; safety.

---

77. MATHER,K.,"Preservation technology: Evaluating concrete in structures". Concrete International: Design Construction,V.7,No.10,Oct.1985, pp.33-41.

A need exists to evaluate the condition of the concrete in a structure whenever a question is raised regarding: (1) the significance of visible evidence of changes, such as cracking; (2) the suitability of the structure for rehabilitation, adaptive reuse, enlargement or extension; (3) the future uses of the structure. Such evaluation may involve visual examination, in-situ nondestructive testing, sampling, and laboratory evaluation of these samples. Laboratory examination techniques include the polarizing microscope, x-ray diffraction, chemical tests, and physical tests.

Keywords: Concrete construction; concrete cores; concrete durability; cylinders; deterioration; evaluation; inspection; nondestructive tests; x-ray diffraction.

---

78. MELLMANN, G. (BAM, Berlin, Germany), "Erfahrungen mit Ultraschallprüfung an Bauwerken aus Beton" (Experiences With Ultrasonic Testing of Concrete Constructions). Proceedings ZfP Bau-Symposium, Berlin, Oct. 2/3, 1985, pp.354-362.

At the Federal Institute for Testing of Materials (BAM) the ultrasonic pulse velocity measurements are caried out by commercially available eqipment and mainly on concrete. It comprises also research work on correlation between material characteristics and ultrasonic measurement data, and also the application of this NDT method in construction work.

Keywords: Concrete; NDT; compr. strength; crack detection; combined NDT method; pulse velocity; detection of defects; pulse velocity; pulse echo; ultrasonic pulse velocity.

---

79. MENEGHETTI, F. and MENEGHETTI, T., "Non-destructive testing to evaluate in-situ maturity on prestressed concrete members". Materials and Structures, Research and Testing (RILEM, Paris), V.18, No.105, May-June 1985, pp. 171-180.

Reports results of an investigation on steam curing prestressed reinforced concrete beams. The "maturity" concept is used to estimate the in-situ cube compressive strength of concrete. During the investigation it was possible to evaluate the characteristies of concrete in-situ, particulary at chosen critical points, without referring to specimens which, having a remarkably different heat inertia from that of the structure they relate to, are not suitable for reliably evaluating maturity. As a result of this investigation, optimization of the curing cycle in the yard was achieved by reducing steam-flow time from 9 to 5 hr, saving considerable energy.

Keywords: Beams (supports); compressive strength; curing; energy; nondestructive tests; reinforced concrete, structural members.

---

80. MIZROKHI, Y.N. et al., "Standard relative to an ultrasonic method to determine concrete frost-resistance" (in Russian). Beton i Zhelezobeton (Moscow), No.4, 1985, pp.28-29.

Introduction of the ultrasonic method to control and estimate frost-resistance according to GOST 26124-84 permits reducing the number of tested samples of 2.5 times and testing duration of 40 percent while it increases control result truth. This method ruled by GOST 26134-84 gives not only frost-resistance of tested concrete but also a real value of frost-resistance.

Keywords: Freze-thaw durability; standards; ultrasonic tests.

81. NEISECKE, J. (Techn.Univ.Braunschweig), "Zerstörungsfreie Ultraschall prüfung von Beton-Erfahrungen aus der Praxis-Weinterentwicklungen in Labor". (Nondestructive Ultrasonic Testing of Concrete-Experience in-Situ-Further Development in the Laboratory). Proceedings ZfP Bau-Symposium, Berlin (Germany), Oct.2/3, 1985,pp.341-353.

Ultrasonic measurements on concrete can be used for observing relative changes in this material or in concrete structures. Some typical examples, using the pulse propagation time measurements for ivestigations of concrete structures are given here.

Keywords: Concrete; NDT; defective concrete: pulse velocity; compr.strength crack detection.

---

82. NESSIM,M.A. and JORDAAN,I.J.,"Models for human error in structural reliability." Journal of Structural Engineering, ASCE,V.111,No.6, June 1985,pp.1358-1376.

Probabilistic models are presented for the occurrence, detection, and consequences of human error in structures. The models are developed in an overall framework of decision theory applied to the problem of allocating control efforts that would narrow the gap between the estimated and actual rates of structural failure. Two models for error occurrence are presented: a binomial distribution for errors in discrete tasks and a Poisson process for errors occurring in a continuous production interval. An application to decision-making in the area of nondestructive testing is also presented.

Keywords: Errors; failure; models; nondestructive tests; performance tests; Poisson ratio; theories.

---

83. OLLIVIER,J.P., "Non destructive procedure to observe the micro - cracks of concrete by scanning electron microscopy". Cement and Concrete Research, V. 15,No.6,Nov.1985,pp.1055-1060.

The study of microcracking is crucial to understandconcrete behavior under loading. Direct observation by a scanning microscope (SEM) is not suitable because the concrete is subject to drying shrinkage. An indirect method of using the SEM is proposed which uses a single replica and can observe microcracking in concrete at any loading levels with a resolution of 0.5 um or better.

Keywords: Concretes; electron microscopes;loads (forces);microcracking; nondestructive tests.

---

84. PLANK, A. (BAM, Bundesanstalt für Materialprüfung, Berlin), "Dringlichkeit und Schwierigkeiten Bei der Bauwerksprüfung" (Urgency and Difficulties of Building Structure Testing).Proc. ZfP Bau-Symposium, Berlin (Germany), Oct. 2/3,1985,pp.29-35.

Maintenance and repair of building structures are of utmost economic importance as almost 60% of our national property is made up in building structures. Methods for checking the performance of a structure are mostly mechanical and simple. Especially are needed methods for early detection of damage, particulary in old structures.The inspection and testing of structures in-situ is difficult as the elements to be tested are often not well accessible.

Keywords: Non-destructive tests; low-destruct. tests; rebound test; mechan. impuls; pulse velocity; ultrasonic pulse; microwave;moisture content; cracking; endoscopy; radiography; conduct.electr.

---

85. REWERTS,T.L.,"Safety requirements and the evaluation of existing concrete buildings". Concrete International: Design & Construction, V.7,No.4,Apr.1985,pp.50-55.

Existing structures don't always behave as they were disigned to behave. This fact creates significant uncertainty for evaluating the strength of an existing concrete structure. A symposium at the 1984 ACI annual convention addressed this problem with nineteen presentations describing test methods, case histories, and statistical approaches in determining the existing condition and remaining life of a structure.

Keywords: Buildings; evaluation; nondestructive tests; reinforced concrete; renovating; safety; strength.

---

86. REYMOND,M.C. and LARTAUT,M.,"Application of acoustic emission to the study of civil engineering materials"(in French).Bulletin de Liaison des Laboratories des Ponts et Chaussees (Paris), No. 140,Nov.-Dec.1985,pp.119-124.

There were two main purposes of this study. The first was to characterize acoustic emission in the function of the mechanism of cracking of roadmaking materials incorporating hydraulic binders. The second was to forecast a possible failure on the bases of analogies between the acoustic emission during natural cracking in civil engineering structures or geologic sites, and the emission of waves in test samples of rock or concrete subjected to stress.

Keywords: Acoustic emissions; binders (materials); construction materials; cracking (fracturing); stresses.

---

87. ROHRMANN-BAUMGART, R.G., (BAM, Berlin),"Theoretische Ermitlung von Bauwerksschäden mit Hilfe Dynamischer Methoden" (Theoretical Investigation of Defects in Structures by use of Dynamic Nondestructive Methods). Proceedinds ZfP Bau-Symposium, Berlin (Germany), Oct.2/3, 1985,pp.341-353.

The following constribution presents some first results of a theoretical investigation of NDT methods in the analysis of structural defects in buildings.These methods are based on an analysis of dynamical measurement results to be obtained when the frequencies and vactors have been measurend.

Keywords: NDT; concrete defects; pulse velocity; ultrasonic frequency; pulse echo.

---

88. SCHICKERT, G., (BAM, Unter den Eichen 87, Berlin),"Heutige Praxis der ZfP im Bauwesen" (To-Day Usage of NDT in Construction), Proceedings, ZfP Bau-Symposium, Berlin, Oct.2/3,1985,pp.91-120, incl. 95 ref. bibliography on NDT publications.

This paper gives a review of about 20 nondestructive or low-destructive testing methods, as well the international standardization in this field. Important problem of the NDT in-situ are considered and the special difficulties due to the influence of time and moisture are discussed. Besides NDT for concrete strength, methods are reported for damage perception with regard to fissures, cavities, irregularities of materials in structure and the concrete cover of reinforcement.

Keywords: NDT; concrete strength; hardness; pull-out; break-off; penetration; magnetic; electro-dynamic methods; ultrasonic pulse velocity; pulse echo; nuclear tests and radiographic method.

---

89. SCHNEIDER,U., (Gesamthochschule Kassel, Germany),"Prüfung von Baustroffen und Bauwerken Durch Schallemissionsanalyse"(Testing Building Materials and Structures by Acoustic Emission Analysis). Proc.ZfP Bau-Symposium, Berlin, Oct.2/3,1985,pp.143-155.

The application of the acoustic emission analysis in the field of NDT of materials offers the possibility to test large structural members in time, whereby the fatique of materials, defects and crack formation can be predicted. The characterization of such effects by specific types of signals may be a~~s~~chieved by the application of complex measurements and evaluation methods which to be standardized yet.

Keywords: Acoustic emission; cracks in concrete; defects location; NDT; pulse velocity; pulse echo.

---

90. SCHNITGER, D., (BAM, Unter den Eichen 87, Berlin), "Verfahrensbezogene Probleme und Schwierigkeiten der ZfP im Bauwesen" (Problems in Application and Difficulties in the Use of NDT in Construction). Proceedings, ZfP Bau-Symposium, Berlin (Germany), Oct.2/3,1985, pp.121-132.

The limits of using NDT methods depend very obviously on the specific material properties, homogeneity of materials, great dimensions, or complexity of a construction , or a great number of parameters depending from each other, may give eminent difficulties when using well known methods. Normal NDT methods must be modified strongly for their use in the field of buildings.

Keywords: Concrete; NDT; electrical method; magnetical m.; pulse velocity m.; radiographic m; nuclear test; ultrasonic test method.

---

91. SCHUSTER, F.O., (Bundesanstalt für Strassenwesen, Bergisch-Gladbach, Germany), "Aufgabenstellung im Strassenbau" (Application in Road Construction). Proceed. ZfP Bau-Symposium, Berlin, Oct.2/3, 1985, pp. 79-88.

The NDT methods are applied in road constructin to perform quality control and contract performance tests on road layers. Electromagnetic and radiometric methods are used to test layers. In the field of condition rating a variety of methods is used: visual inspection, rideability, evenness and bearing capacity measurements.

Keywords: NDT; electromagnetic method; radiometric method; visual inspection; rideability; bearing capacity; density; concrete; subgrade; soil; bitumen layers; moisture content; thickness;

---

92. SEKI.H., "Study relative to the mechanism of expansion cracks due to the corrosion of reinforcing bars" (in Japanese). Cement and Concrete (Tokyo), No. 458, Apr.1985, pp.20-27.

Stimulating tests using the process of electro-corrosion were carried out on reinforced concrete samples to determine the part respectively played on the formation of expansion cracks by four kinds of factors: water-cement ratio, concrete covering, NaCl content, and corrosion electric current. The article is an attempt to elucidate the mechanizm of such cracks, and it deals particularly with the following items: time needed until the formation of cracks; corroded quantity when cracks appear; corrosion speed; relations between the formation of cracks and the expansion pressure.

Keywords: Corrosion; cracking (fracturing); expansion; reinforced concrete; reinforcing steels; sampling; tests; water-cement ratio.

---

93. STANG, H., "Fibre pull-out problem: An experimental investigation". Series R, No.205, Department of Structural Engineering, Technical University of Denmark, Lyngby, 1985, 54 pp.

An experimental method is described for the determination of the parameters involved in a fracture mechanical modelling of a fiber pullout experiment. It is shown that the pullout of steel fibers from a cementitious matrix can be described by means of fracture mechanics, and the experimentally determined parameters are compared with similar parameters determined from other experiments reported in the literature. Furthermore, a method for interfacial crack detection in pullout tests is described. The report contains a short literature review.

Keywords: Composite materials; cracking (fracturing); crack propagation; exstensometers; fibers; load-deflection curve; metal fibers; pullout tests; stiffness.

---

94. STOLL, U.W.,"Compressive strength measurement with the Stoll Tork Test". Concrete International: Design Construction, V.7,No.12, Dec. 1985,pp.42-47.

The Stoll Tork Test (STT)is a new, nondestructive means for assessing the compressive strength within a concrete structure. The prototype device is comprised of a special bolt extension and small, removable cleated spindle which is positioned in the plastic concrete.The configuration assures that at the desired moment, a small aliquot of hardened concrete mortar can be subjected to a semi-confined compressive stress via a twisting force applied by a conventional torque wrench with a memory dial.

Keywords: Compressive strength; concretes; evaluation; nondestructive tests; tests.

---

95. STONE, W.C. and GIZA, B.J.,"Effect of geometry and aggregate on the reliability of the pullout test".Concrete International: Design & Construction, V.7,No.2,Feb. 1985,pp.27-36.

The results indicate that for a fixed value of cylinder compressive strength, the scatter in the pullout ultimate load descreased nonlinearly with increasing apex angles and with decreasing depth of embedment. The presence of aggregate raises the scatter in the ultimate load and also raises the average ultimate pullout load. However, there appears to be no significant difference in scatter, or in the mean ultimate load among the aggregate sizes tested. The four aggregate types showed no effect on the reliability of the test.

Keywords: Aggregate size; aggregates; concretes; embedment; mortars (material); nondestructive tests; pullout tests; reliability; strength; test equipment.

96. WEBER, D., (BAM, Bundesanstalt für Materialprüfung, Berlin) "Einsatz des Rückprallhammers bei der Prüfung von Beton auf Druckfestigkeit" (The Use of Rebound Testhammer in Testing Concrete for Compressive Strength) Proc.ZfP Bau-Symposium, Berlin (Germany), Oct. 2/3,1985,pp.277-286.

In the past ball tests, as well as sclerometer tests were the nondestructive testing methods most frequently used to determine the compressive strength of concrete.Fundamental investigation resulted relatively early in relevant standarts. However, the construction with this method was accomplished in part only, because it measured elastic properties of a thin surface layer of concrete.

Keywords: NDT; concrete compressive strength; elastic rebound; sclerometer; Schmidt test hammer; pendelhammer.

---

97. WITTIG, G., (BAM, Bundesanstalt für Materialprüfung, Berlin) "Elektrische und Magnetische Verfahren für die Prüfung an Bauwerken" (Electrical and Magnetical Methods for Testing of Building Structures). Proceedings ZfP Bau-Symposium, Berlin, Oct.2/3; 1985, pp. 156-169.

In the field of electrical and magnetic methods a number of NDT are available for metallic and nonmetallic materials.The test of components, parts and semifinished products by the application of inductive and magnetic methods has gained a level of high degree of relyability. In the building sector modified techniques serve for localization of reinforcement or concrete cover and to measure road surface thickness.

Keywords: NDT; concrete defects; electrical resistance; electrical conductance ; moisture content; el.-magnetical specter; microwaves; ultrasonic pulse; rebar cover.

---

98. WILLIAMSON, R., "Methods for determining water and cement content of fresh concrete". Materials and Structures, Research and Testing (RILEM, Paris), V.18,No.106, July-Aug.1985,pp. 269-278.

If the concrete does not meet specifications, costly and timeconsuming reconstruction must then take place. Several accelerated tests have recently been developed that reduce the test time from 28 to 1 or 2 days, but still test hardened concrete. The ideal test would be one done on plastic or fresh concrete; thus, methods of analysis are discussed. Of the many factors that affect concrete strength and durability, water and cement contents are most critical. These parameters, expressed in terms of water-cement ratio, provide the best indicators of concrete quality, and are prime factors controlling porosity, strength, and durability of hardened concrete.

Keywords: Compression tests; durability; fresh concretes; porosity; quality control; strength; water-cement ratio.

---

99. WINDISCH, A.,"Modified pull-out test and new evaluation methods for a more real local bond-slip relationship".Materials and Structures, Research and Testing (RILEM, Paris), V.18,No.105, May-June 1985,pp.181-184.

The bond characteristics of reinforcing steels are determined by the well-known pullout and beam tests recommended by RILEM, CEB, and FIP. Some modification in layout and evaluating results are proposed to obtain more real local bond-slip relationships.

Keywords: Bond (concrete to reinforcement); pullout tests; reinforcing steels.

---

100. YENER, M. and CHEN,W.F.,"Evaluation of in-place flexural strength of concrete". ACI Journal, Proceedings V.82,No.6,Nov.-Dec.1985,pp. 788-796.

The differential influence of six potentially significant parameters-aggregate size, aggregate shape, water-cement ratio, age of concrete, curing conditions, and cement type-were examined experimentally to develop empirical relationships correlating breakoff strength and conventional flexural strength of concrete. Conventional cylinders were also tested to determine possible correlation between the breakoff and compressive strengths of concrete. Evaluation of results of 122 breakoff, 140 beam, and 110 cylinder tests indicates that water-cement ratio, age of concrete, curing conditions, and cement type have a significant differential effect on breakoff and beam tests, and that all six of the parameters display a differential effect on breakoff and cylinder tests.

Keywords: Compressive strength; concretes; cylinders; evaluation; flexural strength; nondestructuve tests; statistical analysis.

---

101. ZfP - "Zerstörungsfreie Prüfung im Bauwesen". (Nondestructive Testing in Construction), Proceed. ZfP Bau-Symposium, Berlin (Germany), Oct.2/3, 1985, publ. by German Association for Nondestructive Testing (Deutsche Gesellschaff für Zerstörungsfreie Prüfung e.v., Unter den Eichen 87, Berlin 45)in Germany. ISBN 3-88 314557-2,405 pp.,DM 180.

Symposium was held at the Bundesanstalt für Materialprüfung,BAM (Federal Institute for Testing of Materials) in Berlin, Germany. During the 2-day meeting 8 sessions were held and 30 papers were presented. Abstracts of some of these papers are given earlier in alphabetical order of the authors.

Keywords: Acoustic emmision; break-off method; concrete cracking; concrete strength; dielectric technique; durability; electrical methods; el.-magnetic method; gamma radiography; infrared thermography; magnetic methods; maturity technique; microwave absorption; moisture content; NDT methods; nuclear test; penetration resistance; permeability; pull-out tests; pulse echo technique; pulse velocity; radiometric methods; rebar cover measurement ; rebound hammer; resonant frequency method; ultrasonic pulse method.

1986

102. BACKES, H.P., "Carbonic acid corrosion of mortars containing fly as~~c~~h". Fly Ash, Silica Fume, Slag, and Natural Pozzolans in Concrete, SP-91, American Concrete Institute, 1986,pp.621-636.

The influence of fly ash addition-used as a concrete addition according to the German standard DIN 1045 in exschange for cement-on the resistance of mortar against carbonic acid attack has been investigated. The investigations on mortar prisms stored in water with a carbonic acid concentratio of more than 60 mg CO_2/l for 4 years showed that replacement of cement with fly ash can slow down the rate of attack.

Keywords: Acid resistance; carbonation; cements; chemical attack; compressive strength; corrosion; durability; fly ash; mortars (material); nondestructive tests; porosity.

---

103. BEN-ZEITUN, A.E.,"Use of pulse velocity to predict compressive strength of concrete". International Journal of Cement Composites and Lightweight Concrete (Harlow),V.8,No.1, Feb.1986,pp.51-59.

Prediction of compressive strength of concrete at 28 days and 63 days from pulse velocity at one day and three days is shown.The prediction is made by using pulse velocity and other variables such as water-cement ratio, aggregate-cement ratio, coarse aggregate-sand ratio, amount of cement in the mix, slump, fly ash content, and vebe time.Typical relationship between pulse velocity and compressive strength, and pulse velocity and other variables are also given.

Keywords: Compressive strength; concretes;curing; nondestructive tests; ultrasonic tests; pulse echo technique; strength; tests;

---

104. BIERCHER,M.,(BFI Betriebstechnik GmbH,Düsseldorf)"Durchstrahlungsprüfung von Spann-betonbauwerken" (Radiographic Testing of Prestressed Concrete Structures). Proceedings of ZfP Bau-Symposium Berlin, Oct.2/3,1985,pp.296-310.

Radiography is a method of nondestructive testing,which has been used successfully for years for inspection of prestressed concrete. The choice of the radiation source is determined by the wall thickness of concrete. When using gammagraphy with Ir 192 or Co 60, specimens with a wall thickness up to 30 cm. or 60 cm., respectively, can be examined. By the use of a linear accelerator, inspection of walls of prestressed concrete with a thickness up to 200 cm. can be realized.

Keywords: Concrete; rebar location; gamma rays; radiography; rebar tendons; prestressed concrete.

---

105. BURKE, N.S., "Corrosion rates of steel in concrete-Why worry?". ASTM Standardization News, V.14, No.3, Mar. 1986,pp.57-61.

Describes two nondestructive electrochemical techniques to determine corrosion rates of steel in concrete. Polarization resistance is a low-cost direct-current approach that uses a potentiostat to supply the necessary current to vary the potential between a reference electrode and the specimen away from the corrosion potential, and plots the voltage-versus-current curve on a linear scale. A-C impedance is an advanced technology that analyzes impedance response versus frequency to provide data on the corrosion rate and resistivity of the concrete, and generally displays data on a Nyquist or Bode plot.

Keywords: Corrosion; corrosion tests; reinforced concrete; reinforcing steels.

---

106. DE SITTER, W.R.,et al.,"Acoustic inspection and monitoring of prestressing tendons and bars in concrete structures".CUR Report No.124, Centre for Civil Engineering Research, Codes and Specifications for Concrete, Grouda, Apr.1986, 31pp.

Concrete is relatively new as an offshore construction material.Severe demands are made by the marine environment on the integrity of offshore structures and their extended service life. A major risk is corrosion attack of reinforcing steel and, in particular, prestressing tendons. To minimize the danger of major structural damage, efficient inspection methods are required. As part of the research program, echo-acoustic methods have been developed for locating surface cracks, which allow inspection of concrete structures, both under and above water.

Keywords: Acoustics; concrete cover; concretes; corrosion; cracking (fracturing); inspection; marine atmospheres; offshore structures; prestressing steels; reinforcing steels.

---

107. CHHUY, S. et al.,"Experimental study of damage to concrete"(in French). Bulletin de Liaison de Laboratoires des Pontes et Chaussees (Paris), No.145, Sept.-Oct.1986,pp.37-44.

In the context of a study of the fracture behavior of concrete, an experimental model was built consisting of a large slab measuring 3.00 x 3.5 x 0.12 m. The crack was produced by a flat jack exerting pressure at the rim of a notch in the middle of the longest side. The dimension of a damaged zone in the neighborhood of the bottom of the crack was revealed by different techniques-extensometr measurements by three-dimensional strain gages, acoustic emission, and ultrasonic probes.

Keywords: Acoustic emissions; aggregates; concretes; cracking (fracturing) extensometers; slabs; strain gages; tests; ultrasonic tests.

---

108. DIAZ, L.H. and O'DONNELL, W.,"Quality assurance in concrete". Concrete International: Design & Construction,V.8,No.9,Sept. 1986, pp.67-72.

The quality assurance program for the concrete used in the final stage of Venezuela's Guri Dam was based on a well-trained inspection and testing force and good communications between inspection and computer personnel. Systems were developed to insure effective materials-acceptance testing, concrete production inspection and testing, and concrete construction inspection. Because ice was used as a coolant in concrete production, the monitoring of aggregate moisture content was a critical part of the program.

Keywords: Concrete dams; evaluation; inspection; mix proportioning; quality assurance; quality control.

---

109. GAIDIA,J.M. and ROSENBERG,A.M., "New test for determining fundamental frequencies of concrete". Cement, Concrete, and Aggregates,ASTM, V.8,No.2, Winter 1986, pp.117-119.

The standard methods for determining fundamental frequencies of concrete specimens can be markedly improved by using modern electronic equipment. In the new method, a small accelerometer pickup senses the vibrations of a concrete specimen after it is lightly struck and a spectrum analyzer portrays the information in the frequency domain. The main advantages of the nev method are speed, ability to test small specimens, and no noise. The chief disadvantage is higher equipment cost.

Keywords: Concretes; durability; freeze-thaw durability; nondestructive tests; resonant frequency; sonic tests (resonance).

---

110. GARDNER,N.J. and SAU, P.L.,"Strength development and durability of CSA Type 30 cement/slag/fly-ash concretes for arctic marine applications". Durability of Building Materials (Amsterdam), V.4,No.2,Dec. 1986,pp.179-200.

Describes an experimental investigation into the strength development and durability of CSA Type 30 cement concretes, 50 percent CSA Type 30 cement/ 50 percent slag concretes, and 75 percent Type 30 cement/25 percent fly ash concretes cast at 0°C and cured at 0°C in seawater relative to conventionally cast and cured concretes. All concretes in corporated air-entraining admixtures and had air contents of between 4 and 6 percent.Strength development of all concretes with temperature is dependent upon the water-cement ratio. The resistance to freezing and thawing of Type 30 cement concretes is better than Type 30 cement/slag concretes,which are better than Type 30 cement/fly ash concretes.

Keywords: Aggregates; air-entraining agents; cements; compressive strength; concretes; curing; durability; flexural strength; fly ash; freeze-thaw durability; high early strength cements; nondestructive tests; resonant frequency; seawater; slag; strength; temperature; water-cement ratio.

---

111. GUPTA, S.C., "In-situ strength of concrete: Engineer, builder, and the contract". Indian Concrete Journal (Bombay),V.60,No.2,Feb.1986, pp.45-49,55.

The existing provi~~s~~sions in the departmental specifications and also in the IS code relating to the performance criteria for concrete executed through a contract are inadequate. Various available methods for determining the in-situ strength of concrete, their limitations, and their reliability are included. It also highlights the need for including suitable provisions in the contract to avoid disputes that are likey to arise at a later stage.

Keywords: Compressive strength; concretes; criteria; pullout tests; standards; tests.

---

112. IKEDA,S., "Early estimation of concrete strength from fresh concrete" (in Japanese). Cement and Concrete (Tokyo),No.477,Nov.1986, pp.86-92.

The author draws up the list of standards issued by the Japanese Concrete Institute(JCI) on the early estimation of concrete quality.Through the examples described here, the author gives a comprehensive view of the following items: cement quantitative tests by means of a simple back-titratio method; water-cement ratio tests by means of the measurement of mortar specific gravity; applications to Public Works of the swift hardening method; control of concrete strength by stimulating curing tests; and estimation of water-cement ratio using vibrations.(Cembureau).

Keywords: Durability; fresh concretes; quality control; standards; strength vibration; water-cement ratio.

---

113. JOHN, R. and SHAH, S.P.,"Fracture of concrete subjected to impact loading". Cement, Concrete, and Aggregates,V.8,No.1, 1986,pp.24-32.

To evaluate the response of concrete structures subjected to impact or impulsive loading, it is essential to know how cracks propagate under such dynamic loading conditions. Single-edge notched beams were subjected to varying rates of loading to establish the stress intensity factor K, versus crack velocity V relationship for mortar and concrete. Impact tests were performed using a modified instrumented Charpy test system. During loading, the rate of crack growth was obtained using special brittle Krak gages.

Keywords: Aggregates; compression tests; concretes; crack propagation; dynamic loads; impact strength; impact tests; modulus of elasticity; portland cements; strains; velocity.

---

114. KETTLE, R.J. and SADEGZADEH, M., "Recent research developments in abrasion resistance". Concrete (London), V.20,No.11,Nov.1986,pp.29-31

For many years research has been undertaken to investigate various aspects of the abrasion resistance of concrete, but such work has been almost entirely laboratory based and the findings are not directly applicable to concrete floors in typical industrial environments. To overcome some of these shortcomings, a specific research program was designed and performed. This report summarizes the laboratory and on-site research.

Keywords: Abrasion tests; field tests; nondestructive tests; microstructure; test equipment.

---

115. KROGGEL, O., "Measurement of the concrete cover and the size of the reinforcement bar by magnetic methods". Darmstadt Concrete: Annual Journal on Concrete and Concrete Structures, Institut für Massivbau, Technische Hochschule Darmstadt, V.1,1986,pp.183-190.

The durability of reinforced concrete buildings depends essentially on the proper thickness and the sufficient impermeability of the concrete cover. Protection against corrosion of reiforcement and a stable bond between concrete and reiforcement must be insured. Minimum values of concrete cover are given by many national standards. If they were actually followed correctly, durability would be guaranteed, even if environmental factors get more unfavorable. But mistakes in the state of design and construction works may lead to an insufficient concrete cover.

Keywords: Concrete durability; corrosion resistance; cover; measurement; nondestructive tests; permeability; reinforced concrete; reinforcing steels; standards.

---

116. MANI, K. and LAKSHMANAN, N.,"Determining the extent of damage due to fire in concrete structures by ultrasonic pulse velocity measurements". Indian Concrete Journal (Bombay),V.60,No.7,July 1986, pp. 187-191.

A fire in a concrete structure causes damage to various structural components, the extent of which depends on the intensity and duration of the fire. Ultrasonic pulse velocity measurements are extensively used in evaluating fire-damaged structural elements. A method has been proposed to estimate the core strength as well as the depth of damage in a fire-damaged environment of reinforced concrete structures using ultrasonic pulse velocity measurements.

Keywords: Compressive strength; cracking (fracturing); damage ; deformation; fires; impact hammer tests; modulus of elasticity; pullout tests; resonant frequency; temperature; tests; ultrasonic tests; velocity.

117. MATTI, M.A.,"Frozen concrete". Concrete International: Design Construction, V.8, No.4,Apr.1986,pp.34-41.

A structural concrete slab placed with inadequate protection from winter weather was inadvertently exposed to freezing conditions at an early age. The principal concern was whether it could be rehabilitated or should be totally rejected. Nondestructive techniques were used to determine the quality of the concrete. Accepting or rejecting frozen concrete should be determined only after all relevant information is examined. Subjecting concrete to freezing temperatures at an early age is certainly not advised; however, if it happens it should not be cause for summarily rejecting the concrete.

Keywords: Acceptability; cold weather construction; compressive strength; concrete slabs; evaluation; freezing; fresh concretes; nondestructive tests.

---

118. NASSER, K.W. and AL-MANASEER, A.A.,"Comparison of nondestructive testers of hardened concrete". ACI Materials Journal,V.84,No.6,1986, pp. 374-380.

This paper presents a comparative study of five nondestructive apparatuses for testing hardened concrete in place. The apparatuses are the new pin penetration tester, the rebount hammer, the ultrasonic pulse velocity, the pullout tester, and the penetration probe.Tests revealed that linear and power regression equations were best suited to fit most of the data and to relate it to the compressive strength of the concrete. The tests covered compressive strength in the range of 450 to 3500 psi(3.1 to 24.1 MPa). The new pin penetration tester had a slightly higher coefficient of correlation than the other testers when all the data from the cylinders and the blocks were analyzed together. It was also found that the new pin peneration tester was easy to use and could prove to be very economical.

Keywords: Compressive strength; hardened concretes; impact hammer tests; nondestructive tests; penetration tests; pullout tests; ultrasonic tests.

---

119. NIWA,Y., HIROSE, S. and NAKATANI,S.,"Model studies on scattering of elastic waves in a half space". Proceedings, Japan Society of Civil Engineers (Tokyo), No.368/I-5,Apr.1986,pp.85-94.

Model studies are carried out to investigate the scattering behavior of elastic waves in a half space. The detected waves are simulated by the boundary integral equation (BIE) method. The results show that the observed waves are slightly different from the simulated waves due to the resonance of transducer. In special analyses, therefore, we employ the linear system theory to eliminate the effect of transducer. The obtained frequency spectra reproduce an essential feature of the analytical results computed by the BIE method, except for their absolute values.

Keywords: Earthquake-resistant structures;elastic analysis; nondestructive tests; transducers; ultrasonic tests.

120. ORANTIE, K. and PUNAKALLIO, E.,"Verification of strength of concrete structures by nondestructive methods" (in Finnish).Research Report No.389, Technical Research Centre of Finland, Espoo, Jan.1986, 49 pp.

The purpose of this research was to verity the compliance of in-situ concrete structures with strength requirements using such nondestructive testing methods as the rebound hammer, the ultrasonic pulse technique, and a combination of the two. The influence of wetting of the concrete surface on the accuracy of test results was considered, and the reliability of methods for testing frozen concrete appraised.

Keywords: Compressive strength; concrete construction; nondestructive tests; quality control; specimens; ultrasonic tests.

---

121. RAHARINAIVO,A. et al.,"Relationships between concrete deterioration and reinforcing-steel corrosion". Durability of Building Materials (Amsterdam),V.4,No.2,Dec.1986,pp,97-112.

Reports investigation of the influence of crack geometry in concrete on reinforcement corrosion. The determination in the concrete specimens was due either to carbonation or to chloride penetration. By measuring the electrode potential of the reinforcement, making a visual examination of these steels, and by measuring the carbonated cover depths and the chloride contents, it was possible to draw the following conclusions: cracks increase the apparent diffusivity of chloride, even if their openings are small (about 0.1 mm for a cover thickness of 20 mm); under experimental conditions, steel corrosion was found only in the vicinity of cracks but the rusted lengths were larger than the carbonated cover thickness.

Keywords: Carbonation; chlorides; concretes; corrosion; cover; cracking (fracturing); deterioration; diffusivity; electrical properties; inspection; nondestructive tests; portland cements; reiforcing steels.

---

122. RENGASWAMY, N.S. et al.,"Nondestructive testing of concrete by electrical resistivity measurements". Indian Concrete Journal (Bombay),V.60, No.1,Jan.1986,pp.23-27.

The scope of electrical resistivity measurements as a nondestructive testing technique for concrete structures is examined. It is shown that there is a linear relationship between resistivity and compressive strength development in concrete. Porosity of concrete can also be assessed by measuring resistivity in the dry and water-saturated conditions. An important observation is that a highly porous concrete, in spite of its low strength, can have a very high resistivity value. This study also shows that a battery-operated portable resistivity meter can be conveniently used as a nondestructive testing tool in-situ measurements on concrete structures.

Keywords: Compressive strength; concretes; curing; electrical resistance; nondestructive tests; porosity.

---

123. SANTHAKUMMAR, A.R. et al., "Semi-destructive methods of testing in-situ concrete". Indian Concrete Journal (Bombay), V.60,No.5, May 1986,pp.127-133.

Various semidestructive methods of testing in-situ concrete are discussed briefly. An experimental investigation on concrete through pullout tests with a separately fabricated device is also presented.

Keywords: Compression; concretes; penetration tests; probes; pullout tests; tests.

---

124. SCHMIDT-THRO, G. and STOCKL, S., "Tests on the bond behaviour of deformed bars in slipform concreted structures. Pull-out tests, test specimens produced in Utting"(in German). Bulletin No.378, Deutscher Ausschuss fur Stahlbeton, Berlin,1986,pp.9-38.

Bond behavior is studied by means of pullout tests. The test specimens were concreted in a slipform construction and in ordinary formwork respectively. The mean bond stresses acting at the reinforcement bars are compared for both kinds of specimens. By these tests the ratio of the computed lengths (slipform/ordinary formwork) was found to be approximately 2 for standing bars and 4 for lying bars. If the results are characteristic the allowable bond stresses in Table 19 of the German Standard DIN 1045 have to be reduced: for standing bars, by the factor 0.5, for lying bars, by the factor 0.3. Thus,the anchorage lengths and ovelapping lengths of spliced bars would have to be twice as long as they are now required in DIN 1045.

Keywords: Anchorage (structural); bond (concrete to reinforcement);concretes; pullout tests; reinforcing steels; slipform construction;stresses; walls.

---

125. SEIBLE, F. and HEGEMEIER, G.A.,"Full-scale structural testing". Concrete International: Design & Construction,V.8,No.7, July 1986, pp. 48-52.

The Charles Lee Powell Structural Systems Laboratory at the University of California, San Diego, is one of the few facilities worldwide where full-scale structural systems can be subjected to critical loads in an on-line, computer-controlled multiactuator environment. The structural four-cell box girder test floors provide a 120 x 50 ft test area with tie-down sleeves on a 2 ft module in each direction. The main feature of the 57-ft high bay laboratory is a heavily post-tensioned reaction wall for the full-scale testing of five-story buildings under simulated earthquake loads. The reaction wall dimensions and load capacities make this facility unique in the U.S. Full-scale structural systems testing will provide the long-needed experimental capabilities to verify design procedures and complex analytical models.

Keywords: Floors; laboratories; load tests (structural); structural design; test facilities; walls.

126. SMITH, A.P., "Underwater nondestructive testing of concrete: An evaluation of techniques". Technical Note No. N-1747,U.S. Naval Civil Engineering Laboratory, Port Huenene, Feb. 1986, 48 pp.

Three commercially available instruments for testing concrete above water were successfully modified for underwater use and evaluated in laboratory and field tests. Each instrument represents a different technique for evaluating concrete structures. Instruments for the following methods were tested: a magnetic reinforcing bar locator that can be locate reinforcing bars in concrete structures and measure the amount of concrete cover over the bar; a Schmidt hammer that can be used to evaluate the surface hardness of the concrete and obtain a general condition assessment; and ultrasonic test equipment that can be used to estimate compressive strength, detect cracks, and provide a general condition rating of the concrete based on sound velocity measurements.

Keywords: Compressive strength; concretes; cover; cracking (fracturing); hardness; impact hammer tests; inspection; nondestructive tests; reinforcing steels; ultrasonic tests; underwater structures; velocity.

---

127. SNELL,L.M., WALLACE, N. and RUTLEDGE, R.B.,"Locating reinforcement in concrete". Concrete International: Design & Construction, V.8, No.4,Apr.1986,pp.19-23.

An evaluation of the cover and spacing of reinforcement in an existing concrete structure is usually performed by selective testing and statistical determination. There are two similar but distinctly different reasons why reinforcement cover and spacing may be required: to determine if the reinforcement is in compliance with the contract specifications, and to analyze a building for which the contract documents are not available.This paper illustrates techniques that can be used to analyze both types of structures. The paper also presents the types of statistical information that must be considered in the evaluation of an existing concrete structure.

Keywords: Cover ; evaluation; measuring instruments; position (location); reinforced concrete; reinforcing steels.

---

128. STONE, W.C. and REEVE, C.P., "New statistical method for prediction of concrete strength from in-place tests". Cement, Concrete, and Aggregates,V.8,No.1, Summer 1986,pp.3-12.

A method is presented for determining the functional relationship (correlation curve) between an in-place parameter and the compressive strength of concrete, based on laboratory-conducted tests. The method accounts for the error in both X (in-place) and Y (compressive strength). A statistical procedure is developed for predicting the characteristic strength of concrete in the field, which accounts for the variability of the field-conducted in-place tests, the difference between the coefficients of variation associated with the in-place parameter and the compressive strength, and the error in the laboratory-derived correlation curve.

Keywords: Compressive strength; concretes; construction; statistical analysis; strength.

---

129. STONE, W.C., CARINO, N.J. and REEVE, C.P.,"Statistical methods for in-place strength predictions by the pullout test". ACI Journal, Proceedings V.83,No.5,Sept.-Oct.,1986,pp.745-756.

Pullout tests and companion cylinder tests were conducted to examine variations in ultimate load with respect to concrete strength, and to provide experimental data for the development of a new statistical procedure for predicting in-place compressive strength from the pullout test. The coefficients of variation were found to be relatively constant with average values of 4 percent for cylinder tests and approximately 10 percent for pullout tests in concrete with hard coarse aggregates. A method is presented to determine the appropriate number of in-place tests to be performed for a given concrete placement. A recommended minimum number of 8 to 12 pullout tests per 76 cubic meters (100 cubic yards) is proposed.

Keywords: Aggregates; compressive strength; concrete construction; lightweight aggregates; pullout tests; regression analysis; statistical analysis.

---

130. TAKEUCHI,T., YANAI, M. and YAMAMOTO,T.,"Study on thermal characteristics of concrete for using of thermal infrared sensor".(in Japanese). Concrete Journal (Tokyo),V.24,No.11,Nov.1986,pp.117-126.

The results of an investigation of the thermal characcteristics of concrete using the thermal infrared sensor are described. The thermal infrared sensor has been widely used in the field of remote sensing, but the introduction of this technique to the test of concrete characteristics is considered a possibility.

Keywords: Concretes; cracking (fracturing); mass concrete; nondestructive tests; structural design; thermal conductivity; thermal properties.

---

131. TEODORU, G.V., "Mechanical strength property of concrete at early ages as reflected by Schmidt rebound number, ultrasonic pulse velocity, and ultrasonic attenuation". Properties of Concrete at Early Ages, SP-95, American Concrete Institute, 1986, pp.139-154.

Presents results concerning the correlations between the compressive strength at early ages of concretes hydrothermically treated (steam-cured, cured in heating moulds, and autoclaved) and hardened under standard conditions (20 C and 65 percent relative humidity), and the rebound number R, ultrasonic pulse velocity V, and ultrasonic pulse attenuation A. Different values of the compressive strength of concrete correspond to the same values of nondestructively measured R,V, and A; thus, the absence of information on hardening and curing conditions can cause the results of tests to be misleading.

Keywords: Age-strength relation; coefficient of variation; compressive strength; concretes; curing; impact hammer tests; nondestructive tests; steam curing; ultrasonic tests.

---

132. THEOPHILUS, J., "Uncertainties in assessing the durability of concrete". Civil Engineering (London), Aug.1986,pp.10-13.

The action of carbonation and chlorides are major factors pertaining to the durability of reinforced concrete. Paper discusses methods of measurement of these parameters, the uncertainties involved, and their significance in durability assessment.

Keywords: Carbonation; cement content; chlorides; concrete durability; portland cements; reinforced concrete; x-ray diffraction.

1987

133. BERDOV,G.I.et al., "Prediction of cement material strength in mixes by ultrasonic devices " (in Russian).Beton i Zhelezobeton (Moscow),No.7, 1987, pp.34-36.

A method to forecast strength of building materials based on cement was developed. Method permits the determination in 15 to 20 min of cement strength, mortar-quality class, and concrete class in the mix. When cooling tested samples of cement mix down to 60 C, a variation of the ultrasound propagation time in proportion to cement-stone strength was noted. (Cembureau).

Keywords: Cements; concretes; mixing; mix proportioning; quality control; mortars (material); production methods; strength; ultrasonic tests.

---

134. CARINO,N.J. and STONE, W.C.,"Analysis of in-place test data with spreadsheet software" Computer Use for Statistical Analysis of Concrete Test Data, SP-101, American Concrete Institute, 1987,pp.1-2

In-place testing offers the contractor an alternative to testing field-cured cylinders for assessing concrete strength during critical phases of construction. A relationship between cylinder compressive strength and the quantity measured by in-place tests is needed to use these methods; this requires statistical analysis of test data. The personal computer and "electronic spreadsheet" software provide a cost-effective means of performing such analyses. Available spreadsheet software can be used to perform the required calculations automatically, thus providing the user with the benefits of automated computation without requiring knowledge of a scientific computing language.

Keywords: Compressive strength; computer programs; concrete construction; microcomputers; pullout tests; safety; statistical analysis.

135. DILLY,R.L., BEIZAI,V. and VOGT,W.L., "Analysis of maturity-pullout testing data". Computer Use for Statistical Analysis of Concrete Test Data, SP-101, American Concrete Institute, 1987,pp.27-46.

Pullout testing provides a measurement of in-place strength of concrete, and maturity can be used to estimate strength development. Test statisties are usefuld tools for interpreting the significance of the data. Maturity may correlate to pullout strength by regression analysis. The simplest correlation would be linear using the logarithm of maturity. Linear relationships may be compared using test statisties to determine if slopes and/or intercepts are significantly different. Statistical analysis techniques are used to evaluate pullout strength and maturity data.

Keywords: Age-strength relation; coefficient of variation; computer programs; concretes; evaluation; nondestructive tests; pullout tests; regression analysis; standard deviation; statistical analysis.

---

136. HELLIER,A.K. et al.,"Finite-element analysis of the pullout test using a nonlinear discrete cracking approach". Cement,Concrete, and Aggregates, V.9,No.1,Summer 1987,pp.20-29.

An axisymmetric finite-element model, in which fracture was simulated by means of nonlinear discrete cracking approach, was used to study the pullout test. This type of test involves measuring the force required to extract a conical frustum of concrete by pulling on an embedded steel disk in opposition to a concentric steel-reaction ring at the concrete surface. The precise mechanism of failure, and therefore the strength property of concrete that is actually being measured by the pullout test, has been the subject of several recent studies.

Keywords: Aggregates; concretes; cracking (fracturing); finite-element method; pullout tests.

---

137. HOLLAND,T.C.,"Using the maturity method to predict concrete strength Concrete Construction,V.32,No.10,Oct, 1987, pp.867-869.

Describes the strength-maturity relationhip in concrete and the recently adopted ASTM standard practice for estimating concrete strength by the maturity method, which is based on the temperature history of the concrete.

Keywords: Age-strength relation; concretes; field tests; hydration; measuring instruments; standards; strength; temperature; tests.

---

138. HOLT,F.B. and EALES,J.W.,"Nondestructive evaluation of pavements". Concrete International: Design & Construction, V. 9,No.6,June 1987, pp.41-45.

Infrared thermography and ground-penetrating radar are two proven tools in the growing inventory of pavement management procedures. These nondestructive tests can be used to defect and evaluate various pavement defects, including delaminations in steel-reinforced concrete pavements, debonding of asphalt and concrete overlays, changes in overlay thickness, subsurface deterioration of joints and cracks, and subsurface voids. This article describes the equipment and test procedures used to evaluate each of these pavement defects. Case studies are outlined to demonstrate the speed and accuracy of the procedures under operational conditions.

Keywords: Concrete pavements; deterioration; evaluation; nondestructive tests; radar; temperature measuring instruments.

---

139. KIN CHOU,G. and HOVER,K.C., "Cathodic protection for prestressed structures". Concrete International: Design & Construction,V.9, No.1, Jan. 1987,pp.26-30.

Cathodic protection for reinforced concrete structures has been developed during the past 20 years and has proven to be successful on many full-scale projects. In light of this success, cathodic protection is being considered for control of corrosion in prestressing steel. The differences between conventionally reinforced structures and prestressed structures, in terms of the properties and arrangement of the materials, complicates the design of cathodic protection systems for prestressed structures.

Keywords: Cathodic protection; corrosion; prestressing steels; reinforced concrete.

---

140. KRIVIAK,G.J. and SCANLON,A.,"Estimation of compressive strength of concrete in existing structures based on in-situ test data". ACI Materials Journal, V.84,No.3, May-June 1987, pp. 235-245.

A Bayesian statistics approach is presented for combining compressive strength data from cores and nondestructive test data such as pulse velocity and rebound number, as well as subjective data, to estimate the mean compressive strength of concrete in an existing bridge structure. The sensitivity of the analysis to various factors is discussed. The procedure is illustrated through a parametric study using core data and nondestructive data from an existing bridge structure.

Keywords: Bridges(structures); compressive strength; concrete construction; evaluation; nondestructive tests; statistical analysis.

---

141. LINIERS,A.D., "Microcracking of concrete under compression and its influence on tensile strength". Materials and Structures: Research and Testing (RILEM, Paris),V.20,No.116,Mar.1987,pp.111-116.

A new parameter representing damage of concrete due to compressive stresses is investigated. Very important tensile strength losses are obtained after compressive loading over 40 percent of the compressive strength. Microcracking of concrete takes place under such load,leading to tensile strength losses and depending on time under load, water content,and type of aggregate. Under a maximum compressive load, a tensile strength reduction of about 50 percent is obtained.

Keywords: Aggregates; compression tests; concretes; loads (forces);microcracking; modulus of elasticity; stresses; tensile strength.

---

142. MORI,H. and TANIGAWA,Y.,"Rheological discussions of various consistency tests of fresh concrete" (in Japanese). Journal of Structural and Construction Engineering (Tokyo),V.7,No.377,July 1987,pp.16-26.

Various consistency tests of concrete or mortar,such as slump test, flow test, solid sphere lifting viscometer, and parallel plates plastometer are simulated by using the visco-plastic finite element method, which has been proposed by the authors for simulating the deformation of fresh concrete. The relationship between rheological constant and measured values by these tests are clarified theoretically, and then some problems in measuring rheological constants of fresh concrete are discussed.

Keywords: Consistency tests; deformation; finite element method; flow table tests; fresh concretes; measurement; mortars (material); rheological properties; slump tests; viscometers.

---

143. MURRAY,A.McC. and LONG,A.E.,"Study of the in-situ variability of concrete using the pull-off method". Proceedings, Institution of Civil Engineers (London), Part 2,V.83,Dec.1987,pp.731-745.

This paper describes a program of partially destructive in-situ tests on a multistory car parc to determine the concrete strengths and variability in that structure and includes a detailed analysis of the results. This information is then used to assess the adequacy of the partial safety factor for concrete strength at the ultimate limit state.

Keywords: Concretes; parking facilities; reinforced concrete; research; safety; specifications; strength; structural analysis; structural design; tests; variability.

---

144. NASSER, K.W. and AL-MANASEER, A.A., "Removing concrete forms". Concrete International: Design & Construction, V.9,No.1,Jan.1987, pp.41-44.

Describes a nondestructive test in which a spring-loaded hammer, that drives a small pin into concrete, is used to determine when it is safe to remove concrete forms. The penetration of the pin indicates whether sufficient concrete strength has been attained to permit stripping of forms. Preliminary laboratory tests were carried out on cylinders and slab blocks of diff~~i~~ering compositions at various ages. The compressive, strength for all specimens tested was inversely proportional to the penetration of the pin.

Keywords: Compressive strength; concretes; form removal; lightwei~~i~~ght concretes; nondestructive tests; penetration tests.

---

145. OHTSU,M., "Diagnostic application of acoustic emission to structural integrity of concrete structures" (in Japanese). Concrete Journal (Tokyo), No.12,Dec. 1987,pp.5-11.

Recently, a number of concrete structures in Japan have been approaching their service limit. Therefore, testing techniques for evaluating durability and structural integrity are urgently required and should be established promptly. In this respect, nondestructive evaluation based on acoustic emission (AE) is promising for diagnosing concrete structures. This report summarizes research activity on diagnostic applications of AE to concrete structures.

Keywords: Acoustic properties; acoustics; concrete technology; cracking (fracturing); crack propagation; durability.

---

146. PAUL, M.J.,"Brandywine shoal lighthouse". Concrete International: Design & Construction, V.9,No.6,June 1987,pp.46-53.

A variety of destructive and nondestructive tests were used to evaluate existing conditions and the extent of determination of Brandywine Shoal lighthouse. Founded atop a hazardous shoal next to a busy shipping channel in Delaware Bay, this historic concrete structure has deteriorated severely in the harsh marine environment. The recommended repairs utilize the full spectrum of concrete types, including shotcrete, preplaced-aggregate, tremie, precast and cast-in-place.

Keywords: Corrosion: deterioration; evaluation; freeze-thaw durability; harbor structures; nondestructive tests; precast concrete; repairs; tests.

147. ROY, P.K.S., "Heavy density concrete for nuclear radiation shielding and power stations". Indian Concrete Journal (Bombay),V.61, No.1,Jan. pp.18-22; Feb.pp.40-45, 1987.

The first part of this paper, which appeared in an earlier issue,provided the background information of the sources and effects of nuclear radiation and the aspects involved when selecting materials for heavy-density concrete. The second part presents some of the important properties of heavy - density concrete. The third part discusses mix design, production, quality control, etc., of heavy-density concrete.

Keywords: Chemical analysis; concretes; curing; density (mass/volume); heavyweight aggregates; nuclear pover plants; permeability; physical properties; radiation shielding; thermal properties.

---

148. SAITO, M., "Characteristies of microcracking in concrete under static and repeated tensile loading". Cement and Concrete Research, V. 17,No.2, Mar.1987, pp.211-218.

The type and amount of microcracking in normal weight concrete were determined by the direct observation of the slices cut from the nected prismatic specimens subjected to static and repeated tensile loads. It was found from the results of observation under static tensile loading that bond cracks developed extensively at about 100 percent of the ultimate load. The results under repeated tensile loading indicated that the repetitive nature of loading merely conduced to a slight increase in the total amount of internal microcracking. The relations between these findings and two features of the tensile fatigue previously reported are discussed.

Keywords: Cracking (fracturing); cyclic loads; fatigue (materials); loads (forces); microcracking; static loads; tensile properties; tension.

---

149. SCHONLIN,K. and HILSDORF, H.K., "Evaluation of the effectiveness of curing of concrete structures". Concrete Durability-Katharine and Bryand Mather International Conference,SP-100, American Concrete Institute, 1987,pp.207-226.

A nondestructive rapid test method has been developed for the evaluation of the effectiveness of curing of concrete in the field. With method, air permeability of concrete surface layers is measured wihin a period of about 10 minutes and is expressed in terms of a permeability index. Laboratory experiments show a close correlation between the measured permeability index and the duration of curing, curing temperature, type of cement, water cement ratio, and fly-ash content of the concrete. The method is very sensitive to changes in most parameters that affect the pore structure of the hydrated cement paste and thus the durability of concrete structures under normal exposure conditions.

Keywords: Concrete durability; curing; evaluation; measurement; nondestructive tests; permeability.

150. SCHRADER,E.K.,"Design for strength variability: Testing and effekts on cracking in RCC and conventional concretes." Lewis H. Tuthill International Symposium on Concrete and Concrete Construction, SP-104, American Concrete Institute, 1987, pp.1-26.

ACI and ASTM standards require an overdesign factor to be added to the design strength to account for variability in the mix. There are two key problems with this approach: First, the higher strength requirement necessitates more cement, that in turn results in more water. The result is more shrinkage, increased brittleness, and more crack potential. Second, the amount of overdesign is based on results of cylinder strengths that may not be available until days, weeks, or months after the concrete has been placed. A procedure is presented whereby variability can be based on a set of tests that are performed on the fresh mix as it is made. The variability is known in less than a day.

Keywords: Coefficient of variation; compressive strength; concretes; cracking (fracturing); fresh concretes; mix proprtioning; quality control; roller compacted concrete; shrinkage; strength; tests; thermal stresses; variability.

---

151. SUARIS, W. and FERNANDO,V., "Ultrasonic pulse attenuation as a measure of damage growth during cyclic loading of concrete". ACI Materials Journal, V.84,No.3,May-June 1987,pp.185-193.

This paper presents experimental results of damage growth,is inferred from the reduction in amplitude of ultrasonic waveforms transmitted through the specimen during the test. The amplitude of the waveform, by virtue of its higher sensivity to the extent of cracking, is found to be a better indicator of crack growth than the more often used pulse-velocity technique. A continuous recording of pulse transmission throught the tests is obtained by using a pulse generator, a digital oscilloscope, and a microcomputer.

Keywords: Compression; concretes; cracking (fracturing); cyclic loads; damage; nondestructive tests; ultrasonic tests.

---

152. SUARIS,W. and FERNANDO,V., "Detection of crack growth in concrete from ultrasonic intensity measurements". Materials and Structures: Research and Testing (RILEM,Paris),V.20,No.117,May 1987, pp.214-220.

Results of monitoring crack growth in concrete during uniaxial compression using ultrasonic methods offer the possibility of determining the internal properties of a concrete member both during and after loading without causing any damage. The ultrasonic transducers were designed to monitor pulse transmission in both the axial and lateral directions troughout a uniaxial compression test. The waveforms received at various stages of loading were digitized, stored, and analyzed after the test . The crack growth was inferred from the intensity of these ultrasonic waveforms.

Keywords: Compression tests; concretes; cracking (fracturing); crack propagation; loads (forces); mix proportioning; stress-strain relationships; ultrasonic tests.

---

153. TANAHASHI, I. et al.,"Evaluation of durability for concrete in terms of watertightness by permeability coefficient test results". Concrete Durability-Katharine and Bryant Mather International Conference, SP-100, American Concrete Institute,1987,pp.187-206.

A new type of permeability testing apparatus has been developed that is capable of direct measurement of the permeability coefficient of structural concrete for the purpose of establishing a new method to evaluate the quality and durability of structure concrete in terms of watertightness. Effects of fluidity and mix proportion on the permeability was investigated on typical concrete specimens (disk and hollow disk types). Next, permeability coefficiens of structural concrete (wall and floor) were investigated and evaluation of concrete durability was carried out. The permeability testing apparatus is sufficiently applicable to the structural concrete permeability test and of evaluating the durability of structural concrete.

Keywords: Concrete durability; evaluation; measuring instruments; penetration tests; permeability.

---

154. THORNTON, H.T., JR., and ALEXANDER, A.M., "Development of impact-resonant vibration signature for inspection of concrete structures". Concrete Durability - Katharine and Bryant Mather International Conference. SP-100, American Concrete Institute, 1987,pp.665-681.

Sinusoidal vibration and impact loading techniques have been tested in the laboratory and on field structures. An impact system has been that has proven more economical and versatile than the more commonly used sinusoidal system. With transient loading, a broad band of frequencies (including the resonand frequencies) is appilied to the structure simultaneously rather than sweeping thorough each frequency one at a time. The resonand frequency of a structure is directly related to its dynamic Young's modulus and hence its mechanical integrity. Factors that influence the soundness and safety of a structure such as continuity and boundary conditions also directly affect the resonant frequency.

Keywords: Concrete durability; evaluation; nondestructive tests; piers; resonand frequency; safety; structures.

---

155. YAMADA,K. and KOSAKA,Y., "Damping characteristics of acoustic emission propagating through concrete" (in Japanese). Journal of the Society of Materials Science (Kyoto),V.36,No.406,July 1987,pp.716-722.

The damping characteristics of acoustic emission propagating through concrete were examined to establish the method of acoustic emission source wave analysis. The items chosen in the investigation were the effect of holding technique of sensor, the effects of shape and size of specimen, the effect of degree of heterogenity of material, and the effect of the degree of accumulative damage of specimen. Results are described.

Keywords: Acoustic emissions; cement pastes; concretes; damage; damping; loads (forces); mortars (material); specimens.

1988

156. ACI COMMITTEE 228, "In-place methods for determination of strength of concrete". ACI Materials Journal, V.85,No.5,Sept.-Oct.1988,pp. 446-471.

The state of the art in the use of methods for determining the in-place compressive strength of concrete is reported. The methods covered include the rebound hammer, probe penetration, pullout, ultrasonic pulse velocity, maturity, and cast-in-place cylinder. The underlying principles and inherent limitations of each method are discussed. Repeatability of test results is reviewed, and recommendations are given for developing the correlation relationship for each test method. Recommendations are given for the number of tests, and statistical techniques for interpretation of test results are described.

Keywords: Coefficient of variation; compressive strength; concretes; construction; nondestructive tests; reviews; safety; sampling; statistical analysis.

---

157. ALEXANDER,M.G.,"Use of ultrasonic pulse velocity for fracture testing of cemented materials". Cement, Concrete, and Aggregates,ASTM, V.10,No.1,Summer 1988, pp.9-14.

Describes the use of the ultrasonic pulse velocity technique to measure two important features of facture in notched concrete beams: the extent of the microcracking zone that develops ahead of the noth or crack, and the depth of the main (or stress-free) crack. Beams of 100mm in width and ranging from 100 to 500 mm in depth were tested, and ultrasonic pulses were transmitted longitudinally through the beams at various elevations. Ultrasonic readings taken at elevations above or below the visible crack tip were found to be sensitive to the development of the microcracked zone or to main crack growth, respectively. Based on pulse transit time measurements, the average depth of the microcracked zone was about 44 percent of the residucal beam depth, taking all the beam sizes together. Crack depths estimated from pulse transit times were found to agree with visible crack depths to less than 10 percent on average.

Keywords: Beams (supports); concretes; cracking (fracturing); measurement; microcracking; tests; ultrasonic tests.

---

158. ALEXANDER, A. and THORNTON,H.T., "Developments in ultrasonic pitch-catch and pulse-echo for measurements in concrete". Nondestructive Testing, SP-112, American Concrete Institute, 1988,pp.21-40.

A new improved prototype ultrasonic pitch-catch (two-transducer) and pulse echo (one-transducer) system has been developed for concrete. Signal generation and detection is done with piezoelectric crystals. A literature search revealed that no piezoelectric pulse-echo system had been developed for the ultrasonic range (20 kHz) and that pitch-catch measurements needed further development. No commercial system could be found on the market for making pitch-catch measurements.

Research by the U.S. Army Engineer Waterways Experiment Station has resulted in the development of a 200-kHz pitch-catch system with a signal-to-noise ratio of 18 and a pulse-echo system with a SNR of 8. The mass and dimensions of the improved system have been reduced significantly from the prior state-of-the-art system. The WES system works well for thickness measurements of portland-cement concrete pavement and can indicate the presence of voids.

Keywords: Concrete pavements; evaluation ; measurement; nondestructive tests; thickness; transducers; ultrasonic tests; voids.

---

159. BARKER,M.G. and RAMIREZ,J.A., "Determination of concrete strength with break-off tester". ACI Materials Journal, V.85,No.4,July-Aug. 1988,pp.221-228.

The correlations of the break-off test results with those of the ASTM compression cylinder and the ASTM modulus of rupture beam tests were examined. The variables investigated were the water-cement ratio, the aggregate type, and the maximum aggregate size. In this study, the uncertainties associated with the 75 compression cylinders, 59 modulus of repture beams, and 99 break-off tests were evaluated. Results indicate the break-off test is less influenced by aggregate effects than the modulus of repture beam. The inherent variability of the beam test is not evident in the break-off test. The break-off test better correlates with the compression cylinder. The results show that estimating in situ compressive strengths using the break-off tester seems promising for aggregate sizes up to at least one-half in. (13 mm)maximum. Furthermore, previous studies suggest that the relationship is adequate for larger size aggregates.

Keywords: Aggregate size; compressive strength; concretes; nondestructive tests; variations; water-cement ratio.

---

160. BAZANT, Z.P. and SENER, S., "Size effect in pullout tests". ACI Materials Journal, V.85,No.5,Sept.-Oct.1988,pp.347-351.

Test results on the pullout strength of reinforcing bars embedded in concrete are reported. The test specimens are 1.5,3, and 6-in. cubes with geometrically similar bars. The results are found to be consistent with Bazant's size effect law for the nominal stress at softening failures due to distributed cracking. Based on the size effect law, an approximate formula predicting pullout strength is developed.

Keywords: Bonding; cracking (fracturing); dimensional analysis; embedment; failure; pullout tests; reinforced concrete; reinforcing steels; slippage; tests.

161. BORTOLOTTI, L.,"Double-punch test for tensile and compressive strengths in concrete". ACI Materials Journal, V.85,No.1, Jan.-Feb.1988, pp.26-32.

A method of evaluating the tensile strength in concrete is illustrated by interpreting the failure mechanism from the doublepunch test. A particular Coulomb-like failure criterion is at the basis of this method. Analysis is conducted by considering two succesive limit states through which the structure, represented by a concrete cube, passes. The first state corresponds to the tensile strength reached in the splitting surface, and allows for obtaining an expression both the tensile strength of the material and of its compressive strength by means of the Coulomb-like failure criterion.

Keywords: Compressive strength; concretes; failure mechanisms; mechanical tests; tensile strength; tests.

---

162. BUCK, A.D.,"Characterization of radioactive concrete by petrographic and physical methods". ACI Materials Journal,V.85,No.1,Jan.-Feb. 1988, pp. 55-58.

Portions of a core drilled from radioactive concrete in a dismantled German nuclear reactor were examined by petrographic methods and physical tests. While there was some indication of radiation damage by some of the physical testing, it was concluded from results of the petrographic examination that this was a specimen effect and that there was no radiation damage to the concrete.

Keywords: Concretes; cores; damage; nuclear reactors; petrography; physical tests; radioactivity.

---

163. CARRASQUILLO,P.M., "Pullout tests on straight deformed bars embedded in superplasticized concrete". ACI Materials Journal, V.85,No.2,Mar.-Apr. 1988,pp.90-94.

The bond performance of reinforcing steel embedded in superplasticized normal weight concrete was studied. Pullout tests were conducted on straight deformed bars having an embedded length of either 6 or 8 in. (152 or 203mm). Variables studied were the slump of the concrete before and after the addition of the superplasticizer, the type of superplasticizer used, and the depth of fresh concrete cast under the pullout bars. To determine which properties of the concrete were affected by the addition of the superplasticizer and how these, in turn, affected the bond behavior of the reinforcing bars embedded in that concrete, several properties of the fresh and hardened concrete were tested. These included concrete slump, air content, temperature, bleed, compressive strength, and splitting tensile strength.

Keywords: Air entrainment; bleeding (concrete); bond (concrete to reinforcement); compressive strength; melamine resins; naphthalene; plasticizers; pullout tests; reinforcing steels; splitting tensile strength; temperature; water-reducing agents.

---

164. DILLY, R.L., BEIZAI, V. and VOGT, W.L., "Integration of time-temperature curing histories with PC spreadsheet software". ACI Materials Journal,V.85,No.5, Sept.-Oct.1988,pp.375-388.

An experimental investigation was undertaken to demonstrate the application of spreadsheet software to calculate maturity and correlate maturity with in-place strength development. The results show that when recommended curing practices are followed, "tight" correlations between maturity and in-place strength can result. Paper focuses on the development of spreadsheet templates that allow efficient entry of time-temperature data for maturity computation and correlation with strength. Spreadsheet software can be used as a tool to evaluate curing procedures.

Keywords: Age-strength relation; computer programs; concretes; curing; pullout tests; regression analysis; temperature.

---

165. DILLY,R.L. and VOGT,W.L., "Pullout test, maturity and PC spreadsheet software". Nondestructive Testing,SP-112, American Concrete Institute, 1988,pp.193-218.

Pullout testing and maturity have practical construction applications. Maturity is used to determine curing duration. The pullout test is used to determine in-place strength and to verify the adequacy of cure. Personal computers with spreadsheet software are tools that can benefit concrete construction. Templates developed using spreadsheet software can be used to acquire and analyze relationships between in-place strength and compressive strength, and maturity. Experimental investigations using pullout testing and maturity were undertaken and are reported using graphic features of spreadsheet software.

Keywords: Age-strength relation ; compressive strength; computer programs; concretes; curing; nondestructive tests; pullout tests.

---

166. HARRELL, T.R., "NDT use in evaluating the form removal time for a large diameter tunnel concrete lining". Nondestructive Testing, SP-112, American Concrete Institute, 1988, pp.153-164.

A case history of methods used to evaluate the allowable form removal time for a large diameter tunnel concrete lining is presented. To meet schedule requirements, a concrete placement was to be made every alternate day A triad of testing was done to evaluate the time at which the reusable, self-propelled, steelskinned form could be stripped from an existing placement. This testing consisted of field-cured cylinders and nondestructive testing that included thermocouples in the concrete placements and penetration-resistance testing. Reference curves and tables were developed for use in the form removal evaluation. Statistical methods were used on test data obtained from results of testing done with the actual concrete mix to be used in the placements. Control curves were then developed. Target values were selected to be used in determining when the concrete was of sufficient strength to allow for the form removal.

Keywords: Concretes; form removal; nondestructive tests; penetration tests; thermocouples; tunnel linings.

167. HORIGUCHI,T., SAEKI,N. and FUJITA,Y.,"Evaluation of pullout test for estimating shear, flexural, and compressive strength of fiber reinforced silica fume concrete". ACI Materials Journal,V.85,No.2,Mar.-Apr. 1988,pp.126-132.

The use of pullout strength of steel fiber reinforced concrete (SFRC)to evaluate the shear,flexural and compressive strength of SFRC containing a condensed silica fume is discussed. First, the effect of fiber reinforcement and silica fume addition on pullout strength was investigated with different apex angles of the concrete frustrum. Then the correlations between the pullout strength of steel fiber reinforced concrete and shear strengths were obtained for three types of shear test methods. In addition compressive strength and flexural strength were also correlated with the pullout strength.

Keywords: Compressive strength; concretes; fiber reinforced concretes; flexural strength; metal fibers; nondestructive tests; pullout tests; shear strength; shear tests; silica.

---

168. KIRKBRIDE,T., "Conference clarifies EC concrete codes". Concrete (London),V.22,No.12,Dec.-Jan.1988-89,pp.9-11.

The first of two reports on the Concrete Society conference on design,specification, and workmanship for reinforced concrete construction in 1992. The key to impending changes is the European Community's Construction Products Directive, which will come into effect shortly. The directive provides the legal framework in which Eurocodes, Eurostandards, and Euro-QA will be expected to operate.

Keywords: Concrete construction; reinforced concrete; specifications; standards; structural design.

---

169. MAJI,A.K. and SHAH,S.P., "Application of acoustic emission and laser holography to study microfracture in concrete". Nondestructive Testing , SP-112, American Concrete Institute,1988,pp.83-110.

The fracture process of a composite material involves crushing or slippage of adjacent particles, microcracking; etc.,resulting in changes in the load-versus-displacement behavior. A study of the fracture process is necessary to develop a rational material model. Laser holographic interferometry was applied to study the whole field deformation pattern. Speckle photography was used to measure quantitatively displacement discontinuities at bond cracks at various stages of loading. Acoustic emission (AE) techniques were applied to monitor microseismic activities resulting from the various fracture phenomena. The rate of microfracture was measured from the AE event rates. A source location algorithm was used to calculate the locations of the AE events.

Keywords: Acoustic emission; concretes; lasers; microcracking; nondestructive tests.

---

170. MALHOTRA, V.M., CARETTE, G.G. and BREMNER,T.W.,"Current status of CANMET's studies on the durability of concrete containing supplementary cementing materials in marine environment". Concrete in Marine Environment-Proceedings of the Second International Conference, St. Andrews, NB, 1988,SP-109, American Concrete Institute, 1988, pp. 31-72.

Paper deals with the evaluation in marine environment of normal and lightweight concretes incorporanting supplementary cementing materials. A series of 175 concrete prisms, 305x305x915-mm in size, were cast over a nine-year period starting in 1978 for long-term exposure at Treat Island, Maine. The prisms were positioned at mid-tide level on a rack at the entrance to the Bay of Fundy, which is perhaps the most severe marine exposure condition for concrete. The test specimens are exposed to repeated cycles of wetting and drying, and to an average of about 100 cycles of freezing and thawing per year, up to 9 years. The test specimes are monitored at yearly intervals: the specimens are photographed and rated on a visual basis. Ultrasonic pulse velocity is also determined.

Keywords: Blast furnace slag; compressive strength; concrete durability; fly ash; freeze-thaw durability; marine atmospheres; portland cements; sea water; silica fume; wetting and drying tests.

---

171. MEHTA,P.K., "Durability of concrete exposed to marine environment-A fresh look". Concrete in Marine Environment-Proceedings of the Second International Conference, St. Andrews, NB,1988,SP-109, American Concrete Institute, 1988,pp.1-30.

From recently reported case histories of concrete deterioration in seawater, the author has taken a fresh look at the conclusion presented on this subject at the last CANMET/ACI Conference on the Performance of Concrete in Marine Environment. It is confirmed again that between seawater and the constituents of hydrated cement paste, harmful chemical reactions such as carbonation, sulfate attack, and magnesium ion attack can be limited to the surface when well known measure~~d~~s to assure low permeability of concrete have been put into practice.

Keywords: Concrete construction; concrete durability; corrosion; deterioration; fatigue (materials); marine atmospheres; mix proportioning; permeability; reinforced concrete; reinforcing steels.

---

172. OHTSU, M.,"Diagnostics of cracks in concrete based on acoustic emission". Nondestructive Testing, SP-112, American Concrete Institute, 1988, pp.63-82.

On the basis of the acoustic emission (AE) measuring technique,a diagnostic method for nondestructive evaluation of cracks in concrete is proposed. The diagnostics consist of a mechanical criterion of crack initiation, a quantitative waveform analysis of AE, the evaluation of deterioration by a test of core specimens, and the ultrasonic spectroscopic investigation of cracked members. Results of basic studies on these methods are summarized. Results of basic studies confirm the feasibility and the uselfulness of the proposed method as diagnostics of cracks in concrete structures.

Keywords: Acoustic emission; concretes; cracking (fracturing); nondestructive tests; spectroscopy; stresses; ultrasonic tests.

---

173. OKADA,K., KOBAYASHI,K. and MIYAGAWA,T., "Influence of longitudinal cracking due to reinforcement corrosion on characteristics of reinforced concrete members". ACI Structural Journal, V.85,No.2, Mar.-Apr. 1988, pp. 134-140.

The results of an investigation taking into account longitudinal cracks due to reinforcement corrosion as the limit state in durability design are reported in the paper. First, an application of nondestructive methods for detecting the longitudinal cracks is examined. Then, the effects of various repair methods applied to the beams after longitudinal cracking and the fundamental structural behavior of reinforced concrete beams with longitudinal cracks are investigated.

Keywords: Chlorides; concrete durability; corrosion; cracking (fracturing); deterioration; nondestructive tests; patching; reinforced concrete;strength.

---

174. ONO, K., "Damaged concrete structures in Japan due to alkali silica reaction". International Journal of Cement Composites and Lightweight Concrete (Harlow), V.10,No.4,Nov.1988, pp.247-257.

Cracking in concrete due to alkali-silica reaction (ASR) takes various patterns. In plain concrete and in parts of reinforced concrete structures where there is little or no surface reinforcement, cracking tends to be irregular and maplike. In reinforced and prestressed concrete elements, crackin tends to occur in the direction of the reinforcig bar. Paper presents detailed information on the cracking behavior of a wide range of concrete structures damaged by ASR in Japan. Test data obtained from cores taken from ASR affected concrete structures also are reported. In particular, information is given on crack characteristics, loss of compressive strength and elastic modulus, and the effectiveness of pulse velocity in identifying loss of compressive strength.

Keywords: Alkali-aggregate reactions; compressive strength; concrete construction; cores; cracking (fracturing); damage; durability; expansion; modulus of elasticity; tests;ultrasonic tests.

---

175. PARSONS,T.J.,"Early concrete strength determination by maturity". Nondestructive Testing, SP-112, American Concrete Institute, 1988, pp. 181-192.

Reports results of an investigation into the use of maturity for predicting early-age concrete strengths. Prediction models were developed from cylinder-test results obtained from twelve concrete mixtures cured under three constant curing conditions. A datum temperature of 25 F (-4 C) was used as it appeared to produce the best results. A prediction model based on estimated ultimate concrete strength was used and found to be independent of curing temperature. However, the estimated ultimate concrete strength value appeared to be dependent on curing temperature. The model was verified by using it to predict concrete strength obtained from cylinders and slabs cured outdoors.

Keywords: Age-strength relation; compressive strength; concretes; concrete slabs; cylinders; model~~d~~s; nondestructive tests; temperature.

---

176. PESSIKI,S.P. and CARINO,N.J., "Setting time and strength of concrete using the impact-echo method". ACI Materials Journal, V.85, No.5,Sept.-Oct.1988,pp.389-399.

Tests were performed to evaluate the feasibility of using the impact-echo method to determine setting time and to monitor strength development of concrete. In the impact-echo method, the test object is subjected to point impact and the surface displacement is monitored at a point adjacent to the impact. From the measured displacement waveform and the thickness of the object, the P-wave velocity is determined. Changes in the P-wave velocity with time reveal information about the development of mechanical properties as the concrete matures. Setting-time tests were made on concrete mixtures of two water-cement ratios both with and without set-controlling admixtures. A strong correlation was found between the time of initial setting of mortars, as determined by penetration resistance (ASTM C 403), and the time when the P-wave velocity began to increase.

Keywords: Age; compressive strength; concretes; impact-echo method; mortars (material); nondestructive tests; setting(hardening).

---

177. RINGOT,E., "Development of the map cracking in concrete under compressive loading". Cement and Concrete Research,V.18,No.6, Nov. 1988,pp.933-942.

As a preliminary to modeling fracture of concrete, it is necessary to observe the phenomenon on a small scale. This paper follows the development of microcracks in a sample from a compressive loading experiment where a scanning electron microscope was used during nondestructive testing. A stereological projection method is used to quantify a relationship between observed damages and global behavior of concrete.

Keywords: Compressive strength; cracking (fracturing); loads (forces); map cracking; microscopy; models; nondestructive tests.

---

178. ROBERT,J.L. et al., "Acoustic emission and fracture mechanics as applied to concrete (in French)". Bulletin de Liaison des Laboratoires des Ponts et Chaussees (Paris), No.153,Jan.-Feb.1988,pp.57-64.

The techniques of acoustic emission have been used to study the cracking of concrete in conjunction with research on the possibilities of its application to fracture mechanics. The authors describe the methods employed, attempting to specify their limits and showing the contribution of acoustic emission.

Keywords: Acoustics; concretes; cracking (fracturing); research.

---

179. SANSALONE, M. and CARINO,N.J., "Laboratory and field studies of the impact-echo method for flaw detection in concrete". Nondestructive Testing, SP-112, American Concrete Institute, 1988,pp.1-20.

A nondestructive test method has been developed for locating defects in concrete. The technique is referred to as the impact-echo method and is based on monitoring surface displacements resulting from the interactions of transient stress waves with internal discontinuities. Paper describes the technique and presents results of laboratory studies designed to evaluate the capabilities of the method. These laboratory studies were carried out on 500 mm thick slabs contained a variety of artificial flaws embedded at known locations. Frequency analysis of recorded time-domain waveforms is explained and shown to be a quick and simple signal processing technique. Finally, results are presented from a field study in which the impact-echo method was used to investigate a 150 mm thick slab believed to contain voids.

Keywords: Concretes; concrete slabs; impact; nondestructive tests; ultrasoni tests; voids.

---

180. SANSALONE,M. and CARINO,N.J.,"Impact-echo method". Concrete International: Design & Construction, V.10,No.4, Apr.1988, pp.38-46.

The impact-echo method for nondestructive testing of concrete was successfully used to locate honeycombed concrete and an ungrouted metal duct and to determine the depth of vertical surface-opening cracs in concrete. The studies were carried out on laboratory specimens that contained artificial flaws at known locations. Frequency analysis of recorted surface displacement waverforms was used to determine the location of the various flaws. Finite element studies of the transient impact responde of a solid containing simulated honeycombing were also carried out to again an understanding of transient wave propagation through such a solid.

Keywords: Concretes; finite element method; impact-echo method; impact tests; nondestructive tests; stress waves.

---

181. SHARP, J.V., FIGG,J.W. and LEEMING,M.B., "Assessment of corrosion of the reinforcement in marine concrete by electrochemical and other methods". Concrete in Marine Environment-Proceedings of the Second International Conference, St.Andrews,NB,1988,SP-109,American Concrete Institute, 1988,pp.105-126.

Several projects in the "Concrete in the Oceans" program have measured electrical potentials and resistivities on reinforced concrete specimens exposed to a marine environment. A state of the art survey was also undertaken on corrosion monitoring techniques which led to experimental work to improve the use of these techniques, particulary on marine structures. The main conclusions from this test program are discussed.

Keywords: Concrete durability; corrosion; cracking (fracturing); electrical resistance; electric measuring instruments; marine atmospheres; nondestructive tests; offshore structures; reinforced concrete; reinforcing steels; sea water.

182. SHAYAN, A., "Alkali aggregate reaction in a 60-year-old dam in Australia". International Journal of Cement Composites and Lightweight Concrete (Harlow), V.10,No.4,Nov.1988,pp.259-266.

Examination of drilled cores taken from a 60-year-old dam in Australia has shown that the dam has suffered from alkali-aggregate reaction. Cracking has been observed on the crest of the dam and its concrete railing. The reaction product was characterized by x-ray diffraction, infrared spectroscopy, scanning electron microscopy, and electron microprobe analysis and was shown to be similar to previously reported alkali-aggregate reaction products. New aggregate from the same locality as that used in the dam was tested for alkali reactivity and was found to be reactive with alkali in concrete.

Keywords: Accelerated tests; alkali-aggregate reactions; concrete construction; cores; cracking (fracturing); dams;durability; electron microscopes; expansion; infrared spectroscopy; tests.

---

183. SWAMY, R.N. and AL-ASALI, M.M.,"Engineering properties of concrete affected by alkali-silica reaction". ACI Materials Journal,V.85,No.5, Sept.-Oct.1988,pp.367-374.

A detailed study of the effects of alkali-silica reaction (ASR) on the engineering properties of concrete such as compressive and tensile strength, elastic modulus, and pulse velocity is presented.The results showed that losses in engineering properties do not all occur at the same rate or in proportion to the expansion undergone by the ASR-affected concrete. The two major properties affected by ASR were flexural strength and dynamic modulus of elasticity. Compressive strength was not a good indicator of ASR, but the flexural strength proved to be a reliable and sensitive test for monitoring ASR. Nondestructive tests like dynamic modulus and pulse velocity were also able to identify deterioration of concrete by ASR. The data indicate that critical expansion limits due to ASR would vary depending on the type and use of a concrete structure.

Keywords: Absorption; alkali-aggregate reactions; compressive strength; concrete durability; concretes; dynamic modulusof elasticity; expansion; flexural strength; mechanical properties;tensile strength; tests.

---

184. TAYLOR,M.A.,"Evaluation of concrete constituents using photon radiation". Nondestructive Testing, SP-112,American Concrete Institute, 1988, pp. 41-62.

Gamma-ray absorption techniques were used to determine the amounts of each component in a system of mixtures (such as concrete). The technique uses photons of several energies in contrast to previous applications where only one energy was employed. The use of multiple energies provides more information than the single-beam system, and thus more properties can be determined

Keywords: Absorption; attenuation; concretes; evaluation; gamma rays; nondestructive tests.

---

185. TEODORU,G.V., "Use of simultaneus nondestructive tests to predict the compressive strength of concrete". Nondestructive Testing, SP-112, American Concrete Institute, 1988,pp.137-152.

Aim is to analyze the correlations between several nondestructive measured values (ultrasonic velocity and attenuation, rebound number) and the compressive strength of concrete. A computational program a step-by-step analysis. First, isolated linear correlations are compared with each other in the sense of a general multiple correlation of the values. Since the results obtained from the nondestructive tests are equally scattered, the program determines interactively, in a second step, the multiple coefficients of correlation and restarts the analysis several times by tentatively disregarding the presumably bad experimental results.

Keywords: Attenuation; compressive strength; computer programs; impact hammer tests; nondestructive tests; precast concrete; quality control; ultrasonic tests.

---

186. TURKSTRA, C.J. et al., "Statistical study of the correlation between field penetration strength and field cylinder strength". Nondestructive Testing, SP-112, American Concrete Institute, 1988, pp.165-180.

Presents a comparison of 28 day concrete strength as measured by field probe penetration tests and standard laboratory cylinders. Over a period of 11 monhts, 318 matched sets of tests were performed on 4000-psi concrete at four major projects. Results include the correlation between field and laboratory results. Based on standard statistical tests, it is concluded that the variability of field probe results is similar to that of the corresponding laboratory cylinder tests. Results did not depend significantly on operators or the particular equi~~m~~pment used. It is concluded that the colibration charts provided with the equimpment should be reviewed.

Keywords: Compressive strength; concretes; cylinders; nondestructive tests; penetration tests; probes; statistical analysis; variability.

---

187. YUN, C.H. et al., "Comparative evaluation of nondestructive test methods for in-place strength determination". Nondestructive Testing, SP-112, American Concrete Institute, 1988,pp.111-136.

Presents an ivestigation to determine the within-test variability of various nondestructive test methods (NDT) and the correlation between NDT test results and the corresponding compressive strength of cores. The size effects of coarse aggregate on the variability and correlation were also evaluated. The NDT test methods evaluated in the test series include reboun hammer, pulse velocity, probe penetration, pullout, and CAPO (cut and pullout). Companion tests of field-cured standard cylinders and cores were also made at the ages when the NDT tests were made. There is a good relationship between the results of in-situ tests and the compressive strength. In general, the highest degreeof correlation is for the pullout test followed by that for the CAPO (cut and pullout) test and rebound test, probe penetration test, and pulse velocity test.

Keywords: Aggregates; compressive strength; concretes; curing; evaluation; impact hammer tests; nondestructive tests; probes; pullout tests; ultrasonic tests; variability.

1989

188. AL-TAYYIB, A.J. et al., "Effect of thermal cycling on the durability of concrete made from local materials in the Arabian Gulf countries". Cement and Concrete Research, V.19, No.1, Jan.1989, pp.131-142.

Presents results of a study on the effect of heating and cooling cycles on the durability of concrete made from available limestone aggregates in the Arabian Gulf countries. Specimens of limestone rocks, mortar, and concrete were heated in a temperature-controlled oven to 80 C for 24 hr and then cooled in the oven to room temperature for another 24 hr. After 30, 60, and 90 cycles, specimens were tested for compressive and flexural strengths, pulse velocity, and permeability. It is also indicated that heating and cooling of concrete affects its durability performance as it loses up to 27 and 32 percent of its compressive and flexural strength, respectively. For all tested specimens, the greatest loss of strength is observed after 30 cycles.

Keywords: Compressive strength; concretes; cooling; durability; flexural strength; heating; limestone; permeability; thermal expansion; ultrasonic tests.

---

189. ANSARI, F., "Mechanism of microcrack formation in concrete". ACI Materials Journal, V.86, No.5, Sept.-Oct.1989, pp.459-464.

Formation and extent of microcracks in the fracture process zone of concrete are studied by laser speckle interferometry. Main emphasis is given to detection of microcracks, measurement of the width of microcracking zone, and assessment of process zone length. Crack opening displacements measured within the process zone were substantially higher than the values conventionally measured at the crack mouth. Measured critical process zone lengths (length of the microcracking region at peak load) were found to be specimen size dependent.

Keywords: Concretes; cracking (fracturing); interferometers; lasers; measurement ; measuring instruments; microcracking.

---

190. ASTM "Directory of testing laboratories". ASTM, Philadelphia, 1989, 299 pp., $50, members $40.

Lists the locations and capabilities of testing laboratories that perform services for a fee. The information on the types of tests performed, materials analyzed, or other services offered is based on questionnaires signed and submitted by officers of the laboratories. This edition features: geographical segmentation of listings by contury, state, and city; phone number and contact name for each laboratory; 16 fields of testing; 7 classifications of laboratory services; 12 major categories with 58 subcategories of materials and products; number and type of professionals at each site; branch locations of laboratories; two narrative sections that describe each laboratory's specialty, equipment, testing capabilities, and applications; and detailed subject and alphabetical indexes.

Keywords: Laboratories; test equipment; tests.

---

191. CARINO, N.J. and TANK, R.C., "Statistical characteristics of new pin peneration test". Cement, Concrete, and Aggregates, V.11,No.2,Winter 1989, pp. 100-108.

Describes new test for estimating the in-place strength of concrete. The method, known as the pin penetration test, involves driving a small pin into the concrete surface using a spring-loaded driver. The penetration of the pin creates a small indentation whose depth is measured. The pin penetration is inversely related to the strength of concrete. Paper provides information about the within-test variability of the method and about the correlation relationship between compressive strength and pin penetration.

Keywords: Compressive strength; concretes; cylinders; penetration tests; statistical analysis; variability; water-cement ratio.

---

192. CHENGJU, G.,"Maturity of concrete: Method for predicting early-stage strength". ACI Materials Journal,V.86,No.4,July-Aug. 1989,pp.341-353.

Various expressions of concrete maturity are studied with particular regard to the influences of temperature. A parabolic maturity function is proposed, which is materially identical to one based on the Arrhenius equation of reaction rate. The applicability of various maturity functions as well as strength-maturity equations are reviewed analyzing a series of published data. It is concluded that the maturity concept may serve as an effective means of predicting the early-stage strength of in-situ concrete in spite of its inherent limitations. In addition, the principle and performance of a commercial maturity meter, which are based on the evaporation of liquid, are examined.

Keywords: Age; age-strength relation; compressive strength; concretes; nondestructive tests; setting (hardening); temperature.

---

193. DILLY,R.L. and OLSEN,P.J., "Software uses maturity concept to estimate project duration". Concrete International: Design & Construction V.11,No.8,Aug.1989,pp. 42-51.

Reviews reported maturity-strength relationships and describes a file developed with spreadsheet software to relate maturity-strength data with slab capacity. Other developed spereadsheet files are described that determine required slab capacities for shored floor construction and use maturity-capacity relationships with anticipated curing temperatures to define project curing activities and corresponding durations. Project scheduling software is used to provide generalized shored floor construction logistics. ASCII files, created with spreadsheet software, import estimated curing time requirements for different anticipated curing histories.

Keywords: Age-strength relation; compressive strength; computer programs; concrete construction; curing; form removal; microcomputers; temperature.

---

194. HIROND,S.,"Non-destructive tests of concrete (Principles and methods) Defects, voids, etc". (in Japanese). Concrete Journal (Tokyo), V.27, No.3,Mar.1989, pp.53-58.

Presents methods recently developed for estimating the scaling of surface finishing materials (infrared radiation method, percussion method) and the honeycombs and hollows formed inside concrete (electromagnetic wave method, ultrasonic wave and shock elastic wave method; radiation method). In each case, the principle of the method and the contents of the tests are summar zed. Besides these explanations, tables and diagrams show examples of appl cation of these nondestructive tests. (Cembureau).

Keywords: Concretes; finishes; nondestructive tests.

---

195. GLOVER,J., "Radar roots out concrete features". Concrete (London),V. 23,No.1,Feb.1989,pp.21-22.

Describes the use of ground-probing radar to produce continuous graphic se tions showing such features as concrete thickness, reinforcement distribution, cover depth, girders, fractures, and voids within the concrete in civil engineering structures. Radar also can be used to locate voids beneath concrete ground slabs or behind concrete pipe or tunnel linings.

Keywords: Nondestructive tests; radiography; structural analysis; tests.

---

196. KROGGEL, O."Nondestructive inspection of the integrity of pretensioning wires in floor beams". Darmstadt Concrete (Darmstadt), V.4,1989 pp. 127-134.

It must be assumed that a large number of floor beams expecially used for the construction of farm stables between 1955 and 1970 are severely damaged. A sum of unfavorable conditions, as type and combination of materials used, problems in the fabrication, and the environmental situation, led to the failure of pretensioning wires and in a few cases to the total failure of the ceiling. The large number of beams under suspicion can only be exam ned economically by using nondestructive testing methods, which nevertheless must be reliable, taking into account the high danger coefficient.

Keywords: Beams (supports); construction; floors; nondestructive tests; pretensioning; structural analysis.

197. MAYFIELD,B.,"Close focus testing". Concrete (London),V.23,No.1, Feb. 1989, pp. 20-21.

Describes microscopic methods for determining the cement content and water-cement ratio of hardened concrete that have the following possible applications: identifying aggregate type, cement type, and cement replacement materials; estimating original mix porportions; determining air void content; and investigating chemical and physical durability problems.

Keywords: Cement content; chemical analysis; hardened concrete; microscopy; tests; water-cement ratio.

---

198. MENZEL,K. and PREUSKER,H., "Potential mapping: A method for nondestructive detection of corrosion of reinforcement"(in German). Bauingenieur (Berlin), V.64,No.4,Apr.1989,pp.181-186.

By means of mapping the electric potential, nondestructive detection of corrosion of reinforcement is possible at an early stage. The evaluation and interpretation of potential readings require expert knowledge. This paper gives some information on the theoretical background of this technique and discusses the results of potential mapping at an old concrete structure.

Keywords: Concretes; corrosion; nondestructive tests; structures.

---

199. NASSER,K.W. and DOLAN,D.E.,"Considerations for potential use of nuclear density gages on concrete". ACI Materials Journal, V.86, No.2, Mar.-Apr. 1989, pp.145-149.

The principal intention of this study was to decide if the potential use of nuclear density gages to estimate concrete density might produce results worthy of accurate engineering interpretation. As such, it was important to verify the degree to which the proportions of mixture components affect the interrelationship of density, air content, and compressive strength of concrete to establish the precision of concrete-density estimate required to determine in-situ air content or predict potential compressive strength. The results indicate that if a nuclear density gage can measure the density of concrete to within plus or minus one percent, a value that such a device should be capable of, then the air content and compressive strength of that concrete can be estimated to within an acceptable range.

Keywords: Air entrainment; compressive strength; concrete; density(mass/volume); density measurement; measuring instruments; mix proportioning.

---

200. NAJJAR,W.S. and HOVER,K.C.,"Neutron radiography for microcrack studies of concrete cylinders subjected to concentric and eccentric compressive loads". ACI Materials Journal, V.86,No.4, July-Aug.pp. 354-359.

The neutron radiography technique developed for studying microcracking in concrete is used to investigate the effect of various types of compressive loads on the internal cracking of concrete cylinders. These studies include measurement of the incidence of microcracking in concrete cylinders as a function of concentric load and effect of eccentric loading on internal cracking. Use of the technique has shown a correlation between applied stress and the cumulative length of microcracks, as has been reported previously.

Keywords: Compressive strength; concretes; cracking (fracturing); eccentric loads; microcracking; neutron radiography; nondestructive tests; stress-strain relationships; tests.

---

201. ROSSI,P. and LE MAOU,F., "New method for detecting cracks in concrete using fiber optics". Materials and Structures, Research and Testing (RILEM, Paris), V.22,No.132,pp.437-442.

Research on the use of optical fibers has reached an advanced stage in recent years, especially in the telecommunications industry. A much more recent use of optical fibers to detect such disorders as cracks and damage, e.g., in aeronautics. This article proposes a new civil-engineering application for this method to detect cracks in concrete.

Keywords: Civil engineering; concretes; cracking (fracturing); crack propagation; damage.

---

202. SANSALONE,M. and CARINO,N.J.,"Detecting delaminations in concrete slabs with and without overlays using the impact-echo method". ACI Materials Journal, V.86,No.2,Mar.-Apr. 1989,pp.175-184.

Demonstrates the feasibility of detecting delaminations in reinforced concrete slabs using the impact-echo method, a nondestructive testing technique based on transient stress wave propagation. A study was conducted to show the feasibility of detecting delaminations in reinforced concrete slabs with asphalt concrete overlays. Two reinforced concrete slab specimens with corrosion-induced delaminations were tested. Prior to overlaying the slabs with asphalt concrete, the depths of delaminations as determined by impact-echo testing were verified by drilling at selected points. After the asphalt concrete overlays were applied, the slabs were retested. It was found that the impact-echo method could successfully locate the delaminations in the slabs through the asphalt concrete overlays.

Keywords: Asphalts; concretes; concrete slabs; delaminating; impact-echo method; nondestructive tests; stress waves.

---

203. SIDDIQUI,F.M.A. and BESELER,J.W., "Computing concrete pullout strength". Concrete International: Design & Construction,V.11, No. 2, Feb. 1989, pp. 62-64.

Article assists the designer in computing the concrete pullout strength for anchor bolt configurations. Nondimensionalized area coefficients are plotted for four patterns: 4-bolt, 6-bolt,and two 8-bolt patterns. The Variables used are the center-to-center spacing of the bolts, the depth of embedment, and the diameter of the mechanical anchor heads. It is assumed that, in a particular pattern, all the anchor bolts are of the same type and have the same embedment length.

Keywords: Anchor bolts; computation; concretes; pullout tests; strength; structural design.

---

204. THOMAS,A., "Will 1992 put UK concrete to the test?". Concrete (London),V.23,No.1,Feb.1989, p. 26.

Discusses effects of the coming single European market on the concrete construction industry. The Construction Products Directive introduces "essential requirements"- mechanical resistance and stability; safety in case of fire; hygiene, health, and environment; protection against noise; and energy economy and heat retention-that must be satisfied if a product is to meet new Euro standards. The European Commission has proposed establishing a European Council for Certification and Testing to oversee harmonization of testing and certification among the European nations.

Keywords: Concrete construction; standards; tests.

---

205. TORRENTI,J.M. et al., "Application of stereophoto~~r~~grammetry to the strain localization in concrete". Bulletin de Liaisons des Ponts et Chausees (Paris), No. 159, Jan.-Feb. 1989, pp.105-110.

Several applications of stereophotogrammetry exist. The principle of the method is precisely described and is illustrated with the problem of strain localization in concrete compression. Localization is shown to appear at the stress peak; in such a case, continuum concepts cannot give a good interpretation of such tests.

Keywords: Compression tests; microstructure; photometry; strains; tests.

LIST OF AUTHORS

(Reference numbers)

ACI Committee 228 ----- 156

Akashi,T. ------------ 1,51

Akman, M.S.------------- 2

Al-Asall, M.M.--------- 183

Alexander, A.M.---- 154,158

Alexander, M.G.-------- 157

Al-Hamel, A.H.------- 38,39

Al-Manaseer, A.A.-- 118,144

Al-Tayyib, A.J.-------- 188

Amasaki, S.----------- 1,51

Ansari, F.------------- 189

ASTM Directory of Testing
Laboratories --- 190

Baba, K. --------------- 42

Backes, H.P. ---------- 102

Baker, A.P. ------------ 52

Balabanovic, G. ------73,25

Barker, M.G. ---------- 159

Baumgart, R.G. --------- 87

Baweja, D. ------------- 34

Bazant, Z.P. ---------- 160

Ben-Zeitun, A.E. ------ 103

Beizai, V.------ 45,135,164

Berdov, G.I.----------- 133

Bergstrom, W.R.------------ 63

Bethelst, J.M. ------------ 53

Bickley, J.A. -------------- 3

Biercher, M. ------------- 104

Bjegovic, D. -------------- 73

Bocca, P. ----------------- 4

Bortolotti, L. ------------161

Bremner, T.W. ------------ 170

Buck, A. ----------------- 162

Bungey, J.H. -------------- 5

Burke, N.S. -------------- 105

Cantor, T.R. -------------- 6

Caratin, H. -------------- 37

Carette,G.G. ----------- 7,170

Carino, N.J.---8,9,129,134,176
179, 180, 191, 202.

Carlsson, M.-------------- 10

Carrasquillo, P.M. ------- 163

Chen, W.F.------------- 49,100

Chengju, G.--------------- 192

Chhuy, S. ---------------- 107

Chiarito, V.P. ------------ 24

Chung, H-W. --------------- 54

Czoretti,J.A. ------------- 55

Cziesielski, E. ---------- 56

Dahl-Jørgensen, E. ------- 12
Daniels, R.E. ------------ 17
Dansman, J. -------------- 65
Darter, M.I. ------------- 55
De Sitter, W.R. --------- 106
Dhir, R.K. --------------- 35
Diaz, L.H. -------------- 108
Di Leo, A. --------------- 21
Dilly, R.L.-45,135,164,165,193
Di Maio,. ---------------- 57
Dobmann, G. -------------- 59
Dolan, D.E. ------------- 199
Dorf, V.A. --------------- 13
Dufay, J.C. -------------- 58

Eales, J.W. ------------- 138
Edgar, M.A. -------------- 17
Eeg, I.R. ---------------- 10

Făcăoaru, I. ------------- 14
Fernando, V. -------- 151,152
Figg, J.W. -------------- 181
Fujita, Y. -------------- 167

Gaidia, J.M. ------------ 109
Gardner, N.J. ----------- 110
Giovambattista, A.-------- 57
Giza, B.J. --------------- 95
Glover,J. --------------- 195
Goebbels, J. ------------- 62

Güner, A. ----------------- 2
Gupta, S.C. ------------- 111

Hannant, D.J. ------------ 61
Harrell,T.R. ------------ 166
Hegemeier, G.A. --------- 125
Heidt, H. ---------------- 62
Hellier, A.K. ----------- 136
Hillger, W. -------------- 15
Hilsdorf, H.K. ---------- 149
Hindo, K.R. -------------- 63
Hirond, S. -------------- 194
Hirose, S. -------------- 119
Hoffman, D. -------------- 64
Holland, T.C. ----------- 137

Holt, F.B. -------------- 138
Hönig, A. ---------------- 16
Horiguchi, T. ----------- 167

Hover, K.C. --------- 139,200
Hulshizer, A.J. ---------- 17
Hundt, J. ---------------- 65

Ikeda, S. --------------- 112
Ishida, H. --------------- 40

Jahren, P. --------------- 10
Japan Concrete Institute-18,66

Jenkins, R.S. -------------- 67
Jevtic, D. ----------------- 68
Johansen, R. --------------- 12
John, R. ----------------- 113
Jordaan, I.J. -------------- 82
Jungwirth, D. -------------- 69

Kasai, Y. ------------------ 70
Keating,J. ----------------- 61
Keiller, A.P. ----------- 19,71
Kettle, R.J. ------------- 114
Khoo, L.M. ----------------- 20
Kin Chou, G. ------------- 139
Kirkbride, T. ------------ 168
Kirkby, G. ----------------- 34
Kobayashi, K. ------- 173,28,43
Korolev, M.V. -------------- 72
Kosaka, Y. --------------- 155
Kostrencic, Z. ------------- 73
Krasnovsky, B.M. ----------- 74
Kriviak, G.J. ------------ 140
Kroggel, O. ----------- 115,196

Laloux, R. ----------------- 75
Lakshmanan, N. ----------- 116
Lartaut, M. ---------------- 86
Law, K.-S. ----------------- 54
Leeming, M.B. ----------- 181
Le Maou, F. ------------- 201
Liniers, A,D. ----------- 141
Long, A.E. ----------- 22,143

Malhotra,V.M.---- 7,23,76,170
Mani, K. ---------------- 116
Mather, K. --------------- 77
Matti, M.A. ------------- 117
Mayfield, B. ------------ 197
Mehta, P.K. ------------- 171
Mellmann, G. ------------- 78
Meneghetti, E & T. ------- 79
Menzel, K. -------------- 198
Mikulic, D. -------------- 25
Miyagawa, T. --------- 28,173
Mizrokhi, Y.N. ----------- 80
Mlakar, P.F. ------------- 24
Mori, H. ------------- 42,142
Murray, A.McC.-------- 22,143
Mayers, G.E. ------------- 17

Naik, T.R. --------------- 29
Najjar, W.S. ------------ 200
Nakatani, S. ------------ 119
Nasser, K.W.----- 118,144,199
Nondestructive Testing --- 27

Neisecke, J. -----------15,81
Newman, K. ---------------- 26
Nessim, M.A. -------------- 82
Niesel, K. ---------------- 64
Niwa, Y. ----------------- 119

O'Donnel, W. ------------- 108
Ohtsu, M. ------------ 145,172
Okada, K. ------------- 28,173
Ollivier, J.P. ------------ 83
Olsen, M.P.J. ------------ 193
Ono, K. ------------------ 174
Orantic, K. -------------- 120

Parsons, T.J. --------- 175,29
Pascale, G. --------------- 21
Paul, M.J. --------------- 146
Pessiki, S.P. ------------ 176
Piccardi, J. -------------- 58
Plank, A. ----------------- 84
Prakash Rao, D.S. ------ 30,31
Preusker, H. ------------- 198
Punakallio, E. ----------- 120

Rahazinaivo, A. ---------- 121
Ramirez, J.A. ------------ 159
Rebic, M.P. --------------- 32
Reeve, C.P. ---------- 128,129
Rengaswamy, N.S. -------- 122
Rewerts, T.L. ------------ 85
Reymond, M.C. ------------ 86
RILEM -------------------- 33
Ringot, E. -------------- 177
Robert, J.L.------- 53,75,178
Rohrmann, R.G. ----------- 87
Romanchunk, V.E. --------- 13
Roper, H. ---------------- 34
Rosenberg, A.M. --------- 109
Rossi, P. --------------- 201
Roy, S. ----------------- 147
Rutledge, R.B. ---------- 127

Sadegzadeh, M. ---------- 114
Saeki, N. --------------- 167
Saito, M. --------------- 148
Samarin, A. ------------- 35
Sansalone, M.---- 179,180,202
Santhakumar, A.R.-------- 123
Sau, P.L. --------------- 110
Scanlon, A. ------------- 140
Schickert, G. ----------36,88
Schmidt-Thre, G. -------- 124
Schneider, U. ------------ 89
Schnitger, D. ------------ 90
Schonlin, K. ------------ 149
Schrader, E.K. ---------- 150

Schuster, F.O. ------------ 91
Sener, S. --------------- 160
Seki, H. ----------------- 92
Shah, S.P. ---------- 113,169
Sharma, S.P. ------------- 31
Sharp, J.V. ------------- 181
Shayan, A. -------------- 182
Seible, F. -------------- 125
Siddiqui, F.M.A. --------- 203
Smith, A.P. ------------- 126
Snell, L.M. ------------- 127
Stang, H. ---------------- 93
Stockl, S. -------------- 124
Stoll, U.W. -------------- 94
Stone, W.C.---- 95,128,129,134
Sturrup, V.R. ------------ 37
Suaris, W. ---------- 151,152
Sullivan, B.R. ----------- 24
Suminsby, J.B. ----------- 17
Swamy, R.N. ---------38,39,183

Takabayashi, T. ---------- 40
Tamhankar,M.G. ----------- 31
Tamura, H. --------------- 41
Tanahashi, I. ----------- 153
Tanigawa, Y. ---------- 42,142
Takeuchi. T. ------------ 130
Tank,R.C. --------------- 191
Taylor, M.A. ------------ 184
Teodom, G.V. --------- 131,185
Theophilus, J. ---------- 132
Thomas, A. -------------- 204
Thornton, H.T. ------- 154,158
Torrenti, J.M. ---------- 205
Traversa, L.P.------------ 57
Turkstra, C.J. ---------- 186

Ukrainčik, K. ------------- 25
Uomoto, T. --------------- 43
U S S R ------------------ 44

Vecchio, F.J. ------------ 37
Viola, E. ---------------- 21
Vogt, W.L. ----- 45,135,164,165

Wallace, N. ------------- 127
Walker, R.E. ------------- 24
Weber. D. ---------------- 96
Welsh, J.P. -------------- 46
Whiting, D. -------------- 47
Williamson, R. ----------- 98
Windisch, A. ------------- 99
Winslow, D.N. ------------ 48
Wittig, G. --------------- 97

Yamada, K. --------------155
Yamamoto, T. ------------ 130
Yanai, M. --------------- 130

Yener, M. --------- 49,100

Yoshida, M. ----------- 41

Yun, C.H. ------------ 187

Zerstörungsfreie Prüfung im Bauwesen ------- 101

Zubkov, V.A. ------------- 50